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Symposium on Materials in Transportation to Feature A.S.T.M. Spring Meeting in Detroit

Committee Week Scheduled for March 4 to 8

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THE technical feature of the 1940 A.S.T.M. Spring Meeting, to be held at the Hotel Statler in Detroit on March 6 is a Symposium on Materials in Transportation, stressing especially new materials and advances which have been made in this field. The Detroit District Committee, under whose auspices this meeting will be held, considers the subject to be not only a timely one because of the great strides which have been made in recent years in connection with so-called transportation materials, but also appropriate in considering the industries centered in the Detroit area.

This meeting, which will be held on Wednesday of A.S.T.M. Committee Week, extending from March 4 to 8 inclusive, will be the second such meeting to be held in Detroit, for it was in 1930 that a meeting in Detroit inaugurated the plan of holding so-called regional meetings. Since that time the meetings have grown in importance until today they occupy an important place in the Society's program of promoting knowledge of materials and making available in concise form latest technical information and data on subjects in the field of materials. In 1935, of course, the Society's Thirty-eighth Annual Meeting was held in Detroit. This meeting was one of the most successful yet held, with a number of interesting features including a three-paper Symposium on the Place of Materials in Automobile Roads and Rides.

DETROIT COMMITTEE

The Detroit District Committee, one of the most active, has done a great deal to promote the interests of the Society in the Detroit area. Headed by T. A. Boyd, Head, Fuel Department Research Laboratories Division, General Motors Corp., with C. H. Fellows, Head, Chemical Division, Research Dept., The Detroit Edison Co., as secretary, the members of the committee are prominent technical authorities in this district. Based on the first formal meeting in 1930, the later annual meeting and the several local or district meetings which have been held annually in recent years, it has become well established that whatever the Detroit group does is done well. The forthcoming Spring Meeting will add to the list of outstanding A.S.T.M. functions held in this area.

The technical feature for the meeting, outlined below, has been developed by a Program Committee headed by C. E. Heussner, Materials Engineer, Chrysler Corp. The Banquet Committee headed by C. H. Fellows will be responsible for the program and speaker as well as the dinner that will be held in the evening following the symposium on March 6. A combined Finance—Publicity Group is headed by W. C. Du Comb, President W. C. Du Comb Co., Inc., who has served so efficiently in a similar capacity in connection with other A.S.T.M. meetings. While the plans for inspection trips cannot be certain because of political and business circumstances, a committee has been appointed to follow this matter and to arrange that the wishes of the members in connection with plant trips can be met in so far as possible. This group is headed by F. P. Zimmerli, Chief Engineer, Barnes-Gibson-Raymond, Division of Associated Spring Corp.

Further details of the dinner program, trips and other plans for the committee will be given in the January

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It has been decided in referring to the technical sessions, dinner, etc., held on Wednesday of Committee Week in March to call this "Spring Meeting" rather than "Regional Meeting," the former terminology. When the first auxiliary technical meeting of this nature was held in 1930, it was expected to be of a "regional" nature, but since the meetings have proved of much wider significance than the term "regional" implies and the attendance is definitely not restricted to geographical limits, it is believed the term "Spring Meeting" will be more appropriate.

BULLETIN, and members of the various standing committees meeting during Committee Week will also receive additional details in February.

TECHNICAL PROGRAM

While final details of the technical program have not been announced by Mr. Heussner's committee, the major part of the symposium has been decided upon. A brief outline of the program, including mention of the authors of the papers, leaves no doubt that a technical feature of great value is under way. The subject of fuels and lubricants, stressing particularly recent advances will be developed in two papers, one by D. P. Barnard, Asst. Director of Research, Standard Oil Co. of Indiana, on advance in fuels, with a second paper by members of the staff of Dr. J. B. Rather, in Charge, General Laboratories, Socony-Vacuum Oil Co., covering advances in the development of lubrication and lubricants. S. D. Heron, Research Laboratories, Ethyl Gasoline Corp., and O. E. Harder, Assistant Director, Battelle Memorial Institute, in their paper will cover valve materials.

With respect to the fourth paper, "Developments in Alloy Steel," it is of interest to note that the authors are from four of the largest manufacturers of motor cars as follows: E. W. Upham, Chief Metallurgist, Chrysler Corp.; W. H. Graves, Chief Metallurgist, Packard Motor Car Co.; A. L. Boegehold, Research Dept., General Motors Corp.; and F. E. McCleary, Metallurgical Engineer, Chrysler Corp., Dodge Brothers Division. The fifth paper entitled "Rubber of Tomorrow" is being prepared by S. M. Cadwell, Director, Development Division, Tire Dept., U. S. Rubber Co., and the final paper on the subject of advances in the use of concrete in transportation will be covered by A. J. Boase, Portland Cement Assn.

Further information about this program will be published. It is possible that preparation of the papers may be sufficiently advanced so that abstracts can appear in the January BULLETIN.

COMMITTEE WEEK

As indicated above, the 1940 group meetings of A.S.T.M. committees will be held from Monday, March 4 through Friday, March 8. Many of the committees of the Society have already indicated their decision to hold sessions at this time and others will undoubtedly take part. A list of committees which plan to meet will be included in the January BULLETIN and each committee member will of course receive notice well in advance concerning meetings of the respective groups with which he may be affiliated.

Work will be started in January on the development of a schedule of meetings to avoid conflicting meetings. Considerable effort and time is expended in this study so that the number of conflicts committee members have are kept to a minimum. With so many meetings (in Columbus last year there were 149) a very rigid schedule is frequently necessary but it is considered that the main purpose of Committee Week is still maintained, namely, to permit hundreds of members of different committees to attend in one concentrated period of a few days, meetings of several different groups, thus conserving time and expenses and permitting some members to attend meetings which would not be possible if the meetings were held singly.

Grand Circus Park

Washington Boulevard, left; Bagley Ave., right; Hotel Statler, center.

Detroit

Two hundred and thirty-four years ago there slipped up the Detroit River a fleet of canoes filled with explorers and adventurers, who broke the silence of a vast wilderness with Indian and French accents, and soon carved out of these virgin forests a small settlement of rude huts. This was then an outpost of civilization shivering on the bleak rim of an unexplored wilderness, the savage sentinel of New France. That it has grown and prospered beyond the wildest dreams of its founders is apparent to all.

The Detroit River which connects Lake Erie with Lake St. Clair is the natural boundary between the United States and Canada. At each end are islands—at the north end, Belle Isle, a 1000-acre playground, among the finest city parks in the world. It is closely associated with Indian and French history and was formerly known by the Indians as "Swan Island." It was bought from the Indians in 1789 for eight barrels of rum, a belt of wampum, six pounds of vermilion paint and three rolls of tobacco. Detroit purchased the island ninety years later for $200,000. There was an old French tradition which says that Cadillac gave the island to the people of Detroit so that their cows would not be lost by penetrating deep into the forest, as was common on the mainland.

More river-borne traffic passes Detroit than any other city

in the world—freighters loaded with grain and ore from the northwest and the largest pleasure steamers in the world. It is said that a steamship passes Detroit every three minutes of the season.

Thousands of visitors to Detroit visit the automobile plants of the city every year. Ford, Chrysler, General Motors, Packard, Hudson, Plymouth, Dodge, DeSoto, Lincoln, Reo, Hupp, Oldsmobile, Chevrolet, Buick, LaSalle, Cadillac, Terraplane, Graham-Paige and other automobile and truck plants are all grouped here within a radius of seventy-five miles of Detroit in a giant laboratory of modern mass production. The Detroit area produces ninety-six per cent of all the passenger automobiles built in America.

Detroit has the largest stove manufacturing plant in the world, the largest adding machine, pharmaceutical and electric refrigeration plants, 133 companies manufacturing drugs and chemicals, 57 concerns engaged in airplane manufacturing, 8 aircraft manufacturers, 5 aircraft engine manufacturers, 30 aircraft parts and accessory manufacturers. Detroit has a municipal airport, a Wayne County airport, 10 private landing fields, besides the government landing field on Grosse Ile and the National Guard Field at River Rouge Park. It has the largest copper and brass rolling mills, and is the first in the production of salt and salt products, marine engines, iron, paints and varnishes, freight cars, vacuum cleaners, pins, twist drills, seeds and chairs.

History has touched Detroit frequently. The flags of three nations have flown there at various periods during the conquest of the Northwest. French, British, and Americans—all fought over this strategic spot after the French, headed by Antoine de La Mothe Cadillac, built their stockade here shortly after 1700 to protect the French fur trade in the Northwest from the encroachments of the British. The city came into final possession of the United States after the Revolutionary War. During the War of 1812 the government at Washington sent a detachment of 600 soldiers to defend Detroit against the British and the Indians under Tecumseh, who, like Pontiac, tried to restore the Indiana territory. General Hull, who was in charge of the fort at the time, surrendered finally to the British, but Perry's victory on Lake Erie and the Battle of the Thames, which ended the War in the West, restored Detroit to the United States.

1939 Book of A.S.T.M. Standards in Three Parts

Part I, Metals; Part II, Nonmetallic Materials—Constructional; Part III, Nonmetallic Materials—General

While intensive work is still under way on certain portions of the 1939 Book of Standards, Part III of the book providing the standards and tentative standards covering nonmetallic materials—general, is in the bindery and copies are expected to go in the mails about December 15. The attention of members is directed especially to the fact that the mailing of the books will be in reverse order. Part II will follow about January 1 and Part I, Metals, should be completed and given to Uncle Sam for distribution about the middle of January.

An excellent start had been made last year in the resetting of the standards in Part III, which accounts for this part being completed first. While work on the other two parts has gone on simultaneously, it developed that Part II covering constructional nonmetallic materials could be completed before the volume giving the specifications and tests on metals.

MANY CHANGES IN BOOKS

A number of important changes, first announced a year ago, have been made in this Book of Standards, two being of great significance, namely, the incorporation in each part of all of the respective tentative standards and, second, the publication of the books in three parts rather than two, which was the system used for several of the preceding editions.

The inclusion of tentative specifications and tests, decided upon after very careful consideration, makes the 1939 book of far greater value than any of the previous books. In the past if a member wished to have a complete set of all of the Society's specifications and tests on the subject of say "steel," he had to have not only the respective part of the Book of Standards, but also the current Book of Tentative Standards, the latter being an annual publication. The advantage of having all specifications, whether standard or tentative, in the one volume is obvious.

The publication of the book in three parts was dictated by two factors especially, the size of the books involved, and second, an appropriate division of the materials going into each of the parts. Detailed questionnaires were sent to committee officers and the counsel of a great many of those concerned with specifications was solicited before the final division was made. The overlapping interests of different materials fields was considered and it is believed the final allocation of the respective standards will meet with general approval. The content of the book is divided as follows:

Part I, Metals.—Ferrous and non-ferrous metals (all A and B and some E serial designations) except methods of chemical analysis. General testing methods (E serial designations).

Part II, Nonmetallic Materials—Constructional.—Cementitious materials, concrete and aggregates, masonry building units, ceramics, refractories, pipe and tile, thermal insulating materials (all C serial designations). Timber and timber preservatives, paints, varnishes and lacquers, road materials, waterproofing and roofing materials, soils (certain D serial designations). General testing methods, thermometers (E serial designations).

Part III, Nonmetallic Materials—General.—Fuels, petroleum products, electrical insulating materials, rubber textiles, soaps and detergents, paper, plastics, water (remainder of D serial designations). General testing methods, thermometers (E serial designations).

IMPROVED EDITORIAL STYLE

While the major portion of each part of the book is set in double-column format, certain considerations dictated the use of standing type for some few standards, particularly those that are receiving detailed study preparatory to making extensive revisions which will necessitate resetting.

One other major factor in connection with the books is not readily apparent from a brief examination of the volumes, namely, that the standing committee officers and members, and the staff have spent countless hours improving the material editorially. A determined effort has been made to remove all traces of ambiguity so that there can be no mis-

understanding about the intent of the requirements. Also in many cases where groups of specifications cover somewhat related products, inconsistencies have been eliminated in so far as possible, particularly where sections and paragraphs cover the same respective requirements.

MAKEUP OF BOOK

The same general style will be followed in the makeup of each part of the new book. This provides that all of the *standard* specifications and tests will appear in the first portion of each part, the back portion including the *tentative* specifications and tests. As in previous editions, the respective standard and tentative specifications will be grouped according to the classifications of materials covered. Considerable study has been given to the index which will be complete for each part, and also the tables of contents so as to facilitate the use of the book. The index will of course list each of the specifications and tests under the major subjects covered.

Two tables of contents will provide, first, a subject listing in order of pagination, and second, a listing of titles in numeric sequence of the serial designations. While each table of contents will be complete, that is, listing both standards and tentative standards, there will be provided immediately preceding the tentative standards another table of contents to this portion of the book, this section being printed on colored stock so that it can be turned to readily.

NEW COVER DESIGN

In comparing the latest edition with 1936 from the standpoint of physical appearance perhaps the most striking change will be the design of the backstrap of the book. Considerable thought was given to a design which would make the books distinctive and yet fit in appropriately with a file of the other Society publications such as *Proceedings,* technical volumes, etc. The best way to convey a picture of just what the books will be like is to suggest turning to the advertising section of this BULLETIN where there appears an illustration showing the general design of the books, this illustration having been used in a four-page folder to be used in promoting distribution of the book.

The specifications for binding the book will provide a strong, durable case, and since it was possible economically to obtain a vermin-proof cloth, this was selected, since "book-eating bugs" are a problem in certain parts of the world.

SUPPLEMENTS IN 1940 AND 1941

In connection with previous Books of Standards, Supplements have been issued in each of the intervening years giving specifications and tests that were adopted as standard in the respective years and also giving standards that had been revised.

This same policy will be followed for the 1939 book except that the supplements will not cover the entire book, but there will be a separate volume for each part. Since this supplement will include not only new and revised standards which are adopted, but also tentative specifications and tests published for the first time, each supplement will be quite an extensive publication and will therefore be issued in cloth binding. Supplements to each part will probably range from 200 to 500 pages each.

METHOD OF FURNISHING BOOK TO MEMBERS; PRICES

Several communications have described how the book is to be furnished to members. By the plan in effect members will receive on their dues any one Part of the Book (as they may elect) and its Supplements OR members may procure any two Parts of the Book and their Supplements by paying annually $1.50 OR members may procure all three Parts of the Book and their Supplements by paying annually $2.50.

A scale of the list prices follows and there are given also the members' prices for extra copies of the book:

Sales Prices: (Cloth binding)	Any One Part	Any Two Parts	All Three Parts
1939 Book of Standards and Tentative Standards, Parts I, II, III:			
List Prices (non-members) . .	$8.00	$15.00	$22.00
Members Prices (for extra copies)	5.50	10.00	14.50
Supplements for 1940 and 1941:			
List Prices (non-members)—each year	3.00	5.00	7.00
Members' Prices (for extra copies)—each year	2.00	3.50	5.00

For half-leather binding, add $1.00 for each part and each supplement.

From the above facts it will be seen that membership in the Society is of distinct value with respect to procuring the Book of Standards.

An attractive four-page prospectus in color has been published for use in stimulating the sales and distribution of the book. Copies of this prospectus will be mailed promptly to any members who may wish to use them in their own organizations or for other purposes.

A FEW STATISTICS

The widespread importance of this publication and the fact that it is of direct interest to so many members, a large number of whom could almost be called "joint authors," justify publication of a few facts.

The first Book of Standards was issued just 27 years ago, in 1912. At that time it was termed a "Year Book" and was also part of the *Proceedings* of the Fifteenth Annual Meeting. Fifty-three standard specifications were included covering exactly 250 pages. An annual "Year Book" was issued from 1912 through 1915 and the following year a biennial book was published, then in 1918, publication was on a three-year basis which has continued since. The 1924 Book of Standards included 220 specifications, tests, definitions, etc., the book involving, with indexes, lists, etc., some 1200 pages, and in 1927 the book was issued in two parts, the first covering metals and the second, nonmetallic materials, which practice has been followed until the 1939 edition.

Careful studies have been made of the *quantities* of each part which should be printed taking into account the orders and requests from members, certain advance sales, and the like. Some 21,500 volumes will be published—approximately 8300, Part I; 6700, Part II, and 6500, Part III. With each part covering some 1200 pages, a simple multiplication—number of volumes times the pages—indicates that the total number of pages will aggregate 27,000,000, which is no insignificant printing job.

Application of Sonic Method to Freezing and Thawing Studies of Concrete

By Floyd B. Hornibrook[1]

THE measurement of natural frequencies of vibration of specimens of building materials holds considerable promise as a means of estimating changes in the material caused by aging or by cycles of freezing and thawing or somewhat similar treatments. The natural frequency can be determined at frequent intervals during a given treatment without harming the specimen and the percentage change in the square of the natural frequency may be used as an approximate measure of the breaking down of the structure of the material.

Natural frequencies of vibration of specimens of various materials have been determined in several different ways **(1, 2, 3, 4)**[2] all of which are rapid, accurate, and have no harmful effects on the specimen.

By substituting values of natural frequency into an equation relating that particular frequency to the dimensions of the specimen and the density and elastic constants of the material, a value is obtained for Young's modulus of that specimen. This has been commonly referred to as the sonic method of determining Young's modulus.

Powers **(2)** has compared values for the modulus of elasticity of concrete which were determined by the static and by the sonic methods, and found good agreement. Obert **(4)**, using the sonic method, found for good grade concrete that the no-load modulus was 6 to 10 per cent less than the modulus at one-fourth the ultimate load.

An apparatus for determining the fundamental flexural frequency of a specimen vibrating as a free-free bar has been developed and used at the National Bureau of Standards. This apparatus is somewhat different from and possesses advantages over any heretofore described. A brief description of the apparatus is here presented together with some data obtained with the apparatus in testing concretes subjected to cycles of freezing and thawing.

THEORY

The flexural frequencies of a slender bar of uniform section are given by

$$N = \frac{m^2 k}{2\pi L^2} \sqrt{\frac{E}{\rho}} \quad \ldots\ldots\ldots\ldots (1)$$

where N = natural frequency, cycles per second,

k = radius of gyration of a section (for circular cylinder of diameter d, $k = \frac{d}{4}$),

L = length of specimen,

E = Young's modulus,

$\rho = \frac{\gamma}{g}$

γ = weight per unit volume,

g = acceleration of gravity, and

m = dimensional factor depending on order of mode and on conditions of restraint (for the fundamental flexural mode of a slender free-free bar $m = 4.730$ approximately).

For bars in which the thickness is appreciable compared to the length, a correction is required to account for the effects of rotary inertia and of lateral expansion and contraction of the bar. Mason **(5)** has shown that these corrections can be made by using the proper value of m. The effect of rotary inertia is indicated in graphs of the relation between m and various ratios of thickness to length of rectangular bars vibrating in the fundamental flexural mode, which have been presented by Mason **(5)** and by Powers **(2)**. To obtain the corresponding value of m for a circular bar it is only neces-

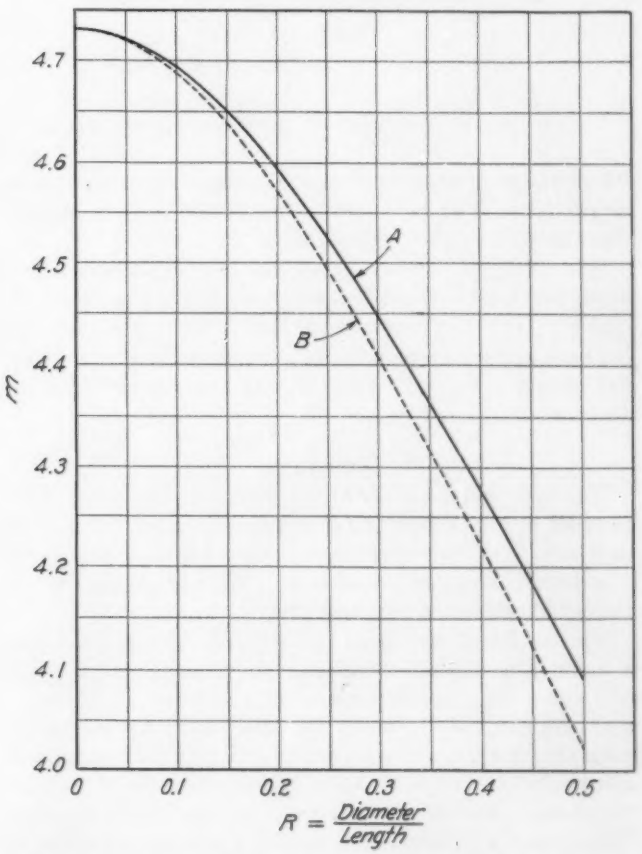

FIG. 1.—Relation Between *M* and the Ratio of Diameter to Length, *R*, for a Circular Bar.

Curve A—Bar vibrating laterally in the fundamental model.
Curve B—Relation after correction has been applied for the lateral expansion and contraction of a concrete bar (Poisson's ratio = 0.16).

[1] Associate Materials Engineer, National Bureau of Standards, Washington, D. C.

[2] The boldface numbers in parentheses refer to the reports and papers appearing in the list of references appended to this paper.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

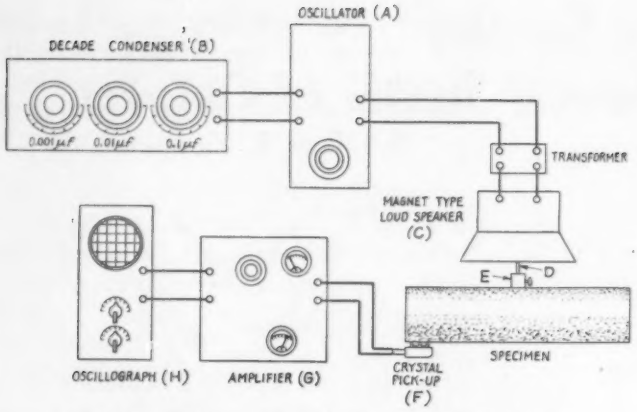

FIG. 2.—Diagrammatic Sketch of Sonic Apparatus.

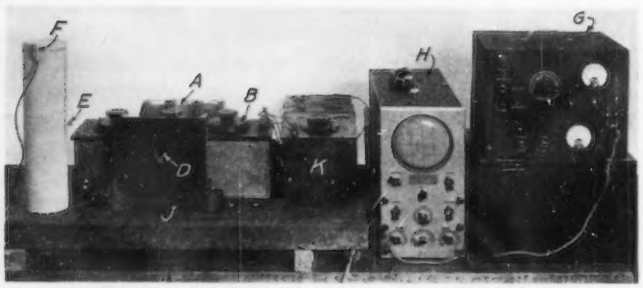

FIG. 3.—Sonic Apparatus and Test Specimen.

sary to multiply the scale of abscissas of the above graphs by $\sqrt{\frac{3}{2}}$ (the ratio of the radius of gyration of a circular bar to the radius of gyration of a rectangular bar of the same thickness). Curve *A* of Fig. 1 shows the relation of m to ratios of diameter to length for circular bars.

The effect of lateral contraction and expansion can be accounted for as shown by Mason by multiplying R by the quantity $(1 + \sigma)^{\frac{1}{2}}$, where σ is Poisson's ratio. The correction has been applied graphically in Curve *B* of Fig. 1 for a material having a Poisson's ratio of 0.16, an average value for concrete.

APPARATUS

The sonic apparatus shown diagrammatically in Fig. 2 and pictured in Fig. 3 consists essentially of a tuned circuit audio oscillator, *A*, a loud speaker, *C*, mounted on a testing frame, *J*, a piezo-electric pickup unit, *F*, a high gain amplifier, *G*, and a cathode ray oscillograph, *H*.

The oscillator[3] has in its circuit a mica decade condenser, *B*, variable in steps of 0.001 μf. for a range of 0.001 to 1.11 μf., and an additional variable air condenser, *K*, having a total capacitance of 0.003 μf. The oscillator is coupled through a transformer to a 6-in. magnet type loud speaker, *C*, a light aluminum rod, *D*, being cemented to the voice coil of the speaker, for transmitting the vibration to the specimen. The speaker is mounted on a channel-iron frame in which are incorporated adjustable standards for supporting the specimen at the nodes.

The piezo-electric pickup is cemented to a light three-pronged brass base so that a three-point contact can be obtained. The pickup is held to the side of the specimen near the end with a rubber band. The output of the pickup unit is fed through a high gain amplifier to a cathode ray oscillograph.

The frequency output of the oscillator was calibrated by synchronizing the sweep circuit of the oscillograph with the 60-cycle power supply, the sweep being synchronized at 60, 120, or 180 cycles per second. The decade condenser of the oscillator was then adjusted so that a fixed number of waves was maintained on the oscillograph screen, corresponding to a frequency which is an exact multiple of the sweep frequency, whose value is given by the number of complete waves appearing. In this way the condenser was calibrated over a frequency range of 200 to 2000 cycles per second. This calibration was checked from time to time and never varied more than 0.5 per cent.

The fundamental flexural frequency of undamaged concrete specimens can be determined with a probable error of less than 0.5 per cent; for specimens partially disintegrated the error becomes somewhat greater because of the spreading out of the resonance peak. In the calculation of the modulus of elasticity of the partially disintegrated specimens the probable error is increased by irregularities in the cross-section due to surface spalling.

TESTING PROCEDURE

The specimen is supported at the nodes (0.224 L from each end) and connected to the voice coil rod by means of a chuck, *E*, Figs. 2 and 3, screwed into a nut cast into the specimen at a midpoint. The frequency of the oscillator is then varied until the amplitude of vibration of the specimen reaches a maximum as shown on the oscillograph. The reading on the frequency dial of the oscillator is then noted. Since many specimens will vibrate at their natural frequency when excited at one-half, one-third, or even one-fourth their natural frequency, care must be taken that the oscillator and specimen are vibrating at the same frequency. This is readily ascertained by synchronizing the sweep frequency of the oscillograph with the oscillator frequency and by placing the pickup unit first on the speaker and then on the specimen; an identical frequency is shown if the same number of waves appears on the oscillograph for each case.

When the measurement of the natural frequency has become of a routine nature, approximately two minutes are required for each separate determination.

EFFECT OF CHANGE IN TEMPERATURE AND MOISTURE CONTENT ON THE NATURAL FREQUENCY OF CONCRETE SPECIMENS

A brief study was made to determine the effect on the natural frequency of small variations in temperature or moisture content of concrete, such as might be encountered during a normal natural frequency determination. The results are summarized in Tables I & II. The data indicate that the effects of these two variables are negligible for any changes which are apt to occur in normal practice. Furthermore, it appears that small moisture changes in a saturated or nearly saturated specimen have little effect, indicating that the

[3] An oscillator easy to construct and simple to operate which should prove admirably suited for use in sonic apparatus is described by Cledo Brunetti, "The Transition Oscillator," *Proceedings*, Inst. Radio Engrs., Vol. 27, February, 1939, p. 88.

Table I.—Effect of Change in Temperature of Specimen on Natural Frequency

Dry Specimen; Initial Temperature 200 F.				Saturated Specimen; Initial Temperature 35 F.			
Time After Being Placed at 75 F.		N, cycles per sec.	Change, per cent	Time After Being Placed at 75 F.		N, cycles per sec.	Change, per cent
min.	hr.			min.	hr.		
5		1716		5		1870	
30		1720			4	1855	−0.8
	1	1725					
	2	1736					
	4	1743	+1.6				

Table II.—Effect of Drying of Specimen on Natural Frequency

Time of Air Drying Starting with Saturated Specimen		Loss in Weight, per cent	N, cycles per sec.	Decrease in N, per cent
min.	hr.			
0	0		1873	
20			1870	...
	1		1875	...
	18	0.45	1854	1.0
	24		1850	1.2
	46	0.72	1855	1.0
	68		1851	1.2
	118	1.43	1851	1.2
	142	1.63	1854	1.0
Overnight drying in oven at 200 F.		3.72	1709	8.8

saturated condition is well adapted for obtaining reproducible measurements on companion specimens. Oven drying causes considerable change in the natural frequency of the specimen.

COMPARISON OF CHANGES IN MODULUS OF ELASTICITY AND CHANGES IN STRENGTH OF CONCRETE SPECIMENS SUBJECTED TO FREEZING AND THAWING

A brief series of tests was made to determine whether the sonic method of measuring the changes in modulus of elasticity would give a suitable indication of the disintegrating action of freezing-and-thawing treatment of concrete.

In making the tests one standard portland cement was used. Concrete specimens (1:3.14:2.87 with $\frac{3}{4}$ in. maximum size aggregate) of three different cement-water ratios were made in duplicate for each of five freezing-and-thawing conditions. The specimens (4 by 16-in. cylinders) were damp-cured one day and were then placed under water until time of test. At the age of six weeks the fundamental flexural frequency was determined; then the specimens were sealed in tight-fitting rubber bags, sufficient water having been added so that the specimens were surrounded with a thin layer of water. The specimens were frozen immersed in an alcohol-water freezing mixture.

The five freezing-and-thawing conditions to which the specimens were subjected were as follows: series I, —20 F. to 70 F.; series II, 0F. to 70 F.; series III, 20 F. to 70 F.; series IV, —20 F. to 35 F.; series V, 25 F. to 35 F. The normal cycle consisted of 2 hr. freezing and 2 hr. thawing; however, the specimens were left at the thawing temperature at night and over week-ends. It was determined from time-temperature observations with embedded thermocouples that 2 hr. were sufficient for the center of the specimen to reach the approximate temperature of the freezing medium.

At the end of each three cycles the specimens were removed from the rubber containers, immersed overnight in water, and the fundamental flexural frequency determined by the sonic method.[4] Those specimens showing but small change after 30 cycles were tested thereafter at every six cycles.

Young's modulus E was determined from Eq. 1 by solving for E, and for a 4 by 16-in. cylinder, substituting $k = 1$, $L = 16$ and $m = 4.495$ (from Fig. 1, Curve B) then

$$E = 16.3\ N^2\ \gamma$$

where N = the fundamental flexural frequency in cycles per second, and

γ = the unit weight of the specimen in pounds per cubic inch.

Equation 1 holds only for a bar of constant cross-section and for linear distribution of the bending stress. In partially disintegrated specimens the cross-section frequently is

[4] It was found that the natural frequency of a specimen changed materially during the first 24 hr. after completion of the freezing-and-thawing cycle; hence the uniformity of results required the elapse of a constant interval of time between the completion of the cycle and the frequency determination.

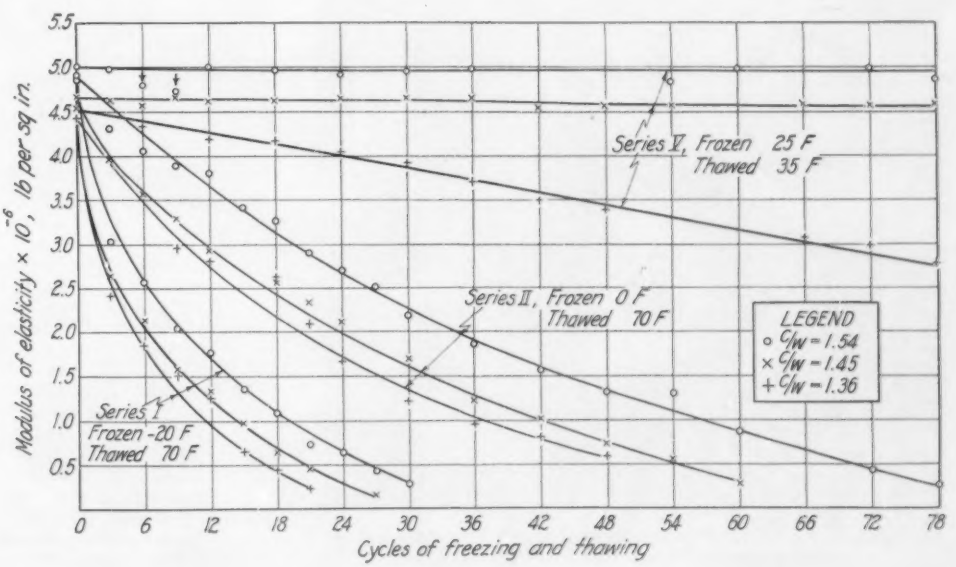

FIG. 4.—Change in Modulus of Elasticity with Increasing Number of Cycles of Freezing and Thawing. Each Point is the Average of Two Specimens.

not uniform and in all likelihood the applied stress is not linearly distributed. However, the value obtained can be considered as an apparent Young's modulus which is characteristic of that specimen.

Figure 4 shows the change in modulus of elasticity with increasing cycles for three conditions of freezing and thawing. The series frozen at —20 F. and thawed at 35 F. followed approximately the curves shown for the —20 F. to 70 F. series. The series frozen at 20 F. and thawed at 70 F. gave essentially the same results as those shown for the 25 F. to 35 F. series.

As can be seen from Fig. 4, there is fairly consistent separation of the concretes of different cement-water ratios after the early cycles. Of the group frozen and thawed at 25 F. and 35 F., respectively, it is notable that the concretes made of the two drier mixes were practically unaffected by the continuing treatment, whereas the concrete of the wetter mix was affected materially.

The freezing-and-thawing treatment was terminated either after 78 cycles of freezing and thawing or after a reduction in apparent Young's modulus of 94 to 98 per cent from the modulus of standard reference specimens of the same age. The dimensions and unit weights were then redetermined and each specimen broken in flexure (12-in. span). One of the remaining halves of each specimen was then capped with plaster of Paris and broken in compression; the other half-specimen was kept for other tests.

Table III gives a comparison of the decreases in moduli of elasticity, moduli of rupture, and compressive strengths of all individual specimens, and the cycle at which the freezing and thawing was terminated. The values for the decreases are based on separate determinations on unfrozen specimens at the approximate age of the termination of freezing tests. However, a value was obtained for only one reference specimen in each case, except for the modulus of elasticity, where companion specimens were available.

Table III.—Decrease in Moduli of Elasticity and Rupture and in Compressive Strength at End of Freezing-and-Thawing Treatment

	Freezing-and-Thawing Temperatures, deg. Fahr.	Cement-Water Ratio	Specimen	Decrease in Modulus of Elasticity, per cent	Decrease in Modulus of Rupture, per cent	Decrease in Compressive Strength, per cent	Cycle at Which Test was Terminated
Series I	−20 to 35	1.54	No. 15	97	95	77	24
			No. 16	95	92	66	24
		1.45	No. 24	95	95	78	21
			No. 25	97	95	79	21
		1.36	No. 33	95	93	75	15
			No. 34	98	92	71	18
Series II	−20 to 70	1.54	No. 1	95	93	63	30
			No. 2	95	92	66	33
		1.45	No. 4	96	96	72	27
			No. 5	98	97	83	27
		1.36	No. 7	97	94	63	21
			No. 8	96	93	78	24
Series III	0 to 70	1.54	No. 3	96	94	58	78
			No. 10	94	92	70	78
		1.45	No. 6	97	95	73	60
			No. 19	95	92	67	66
		1.36	No. 9	94	94	60	48
			No. 28	96	92	52	66
Series IV	20 to 70	1.54	No. 11	1	23	17	78
			No. 12	5	5	10	78
		1.45	No. 20	−2	1	31	78
			No. 21	1	23	42	78
		1.36	No. 29	6	14	−5	78
			No. 30	10	2	25	78
Series V	25 to 35	1.54	No. 13	8	−2	11	78
			No. 14	7	14	9	78
		1.45	No. 22	1	12	39	78
			No. 23	8	25	51	78
		1.36	No. 31	35	39	24	78
			No. 32	11	18	44	78

From the data in Table III it can be seen that excellent concordance was obtained between companion specimens in most cases. There was also good concordance for companion specimens for the decrease in moduli of rupture for the three series which were severely affected by the freezing and thawing.

There is excellent agreement between the decrease in moduli of elasticity and moduli of rupture for the three series severely affected. Aside from two outstanding exceptions the agreement is also good for the other two series. The values for the decrease in the compressive strengths of the last two series, however, appear to have no relation to the values for the decrease in moduli of elasticity or rupture. It is probable that the erratic results obtained in the compression and flexural tests can be largely ascribed to the external conditions of the specimens, the surface of most of the specimens being considerably eroded in the mid-section, at the end of the 78 cycles.

The number of the terminating cycles, for each series severely affected, is in increasing order with increasing water content of the concrete (decreasing cement-water ratio).

SUMMARY AND CONCLUSIONS

1. The fundamental flexural frequency of a specimen can be determined rapidly and at frequent intervals with the sonic apparatus. Converting the frequencies into values for Young's modulus gives a continuous history of the change in modulus of elasticity of a single specimen during a given type of treatment or test.

2. The natural frequency of a specimen of concrete is affected only slightly by temperature changes or by moisture changes in relatively moist concrete. Oven drying causes considerable change in the natural frequency.

3. For those specimens having a loss in flexural strength caused by freezing and thawing, of 92 per cent or greater, excellent concordance was obtained between the percentage decrease in modulus of rupture and modulus of elasticity. For those specimens less severely affected the agreement between the two measurements, in general, was not as close, though still close enough to be useful.

4. The sonic method of determining the change in modulus of elasticity appears well adapted for estimating the loss of flexural strength produced in concrete by freezing-and-thawing treatment.

ACKNOWLEDGMENT

Acknowledgment is expressed to E. A. Pisapia for fabricating the test specimens and making the freezing-and-thawing tests.

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California Practice in Obtaining Undisturbed Soil Samples

By T. E. Stanton, Jr.[1]

Most soil explorations in California are made with a special soil sampler designed by Engineers of the Materials and Research Department of the California Division of Highways[2]. Two sizes are regularly used, (*a*) a heavy power-operated sampler designed for deep borings, ranging up to 200 ft. or 300 ft. in depth and (*b*) a light-weight sampler for hand operation.

POWER SAMPLER

The power sampler (Figs. 3 and 4) is operated with a combination drilling rig (Figs. 1 and 2).[3] Conventional churn drills or a heavy diamond drilling machine is used to drive and pull the sampler whenever there is more work than can be handled with the combination drill. This sampler has been successfully used for the past 7 yr. for obtaining undisturbed cores 2 to 4 in. in diameter.

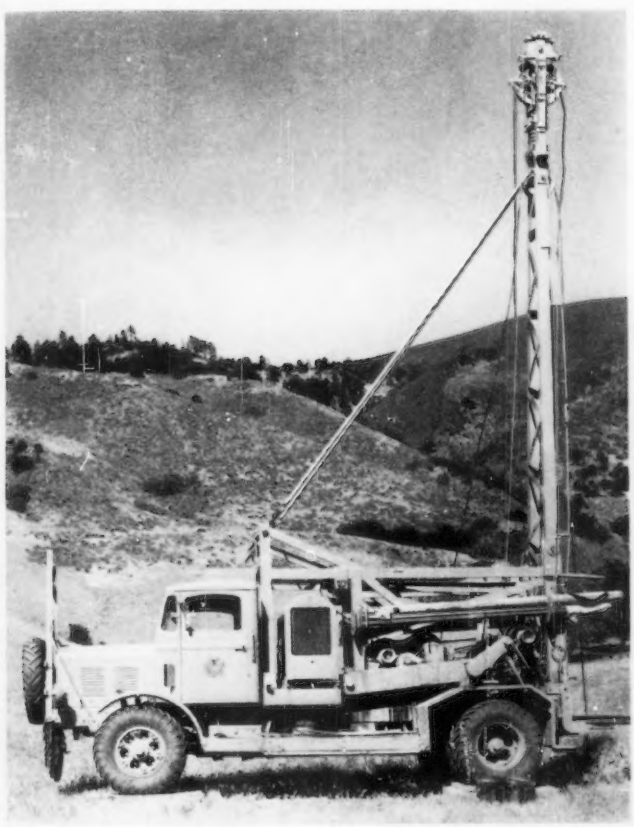

FIG. 1.—Combination Foundation Drilling Rig.

Experience indicates that 2-in. samples are sufficiently large for satisfactory tests of compressible clay deposits. The 2-in. sampler, therefore, is normally used as it can be operated at a somewhat lower cost than the heavier equipment required for 3 and 4-in. cores.

Borings have been made to depths ranging between 60 and 300 ft., at an average cost of approximately $1.00 per foot, including rental of equipment and all operating expenses. Similar sampling with other methods usually costs two to four times this amount. Part of the lower cost results from the fact that casing is not required for borings up to 100 ft. in depth unless free flowing sand and gravel layers are encountered.

DESCRIPTION OF SAMPLER

The sampler unit (Figs. 3 and 4) consists of a cutting point, five sampler sections, couplings and a plug, screw, and nut assembly. The sampler sections, couplings and the cutting points are bored out on the inside to receive brass tube sample retainers, 2 or 4 in. in length. These brass tube retainers (Fig. 5) permit ready removal of the cores from the sampler and prevent disturbance of the specimens.

The important element of this type of sampler is the plug assembly. First, it plugs the sampler until the depth is reached at which samples are desired, and second, it provides

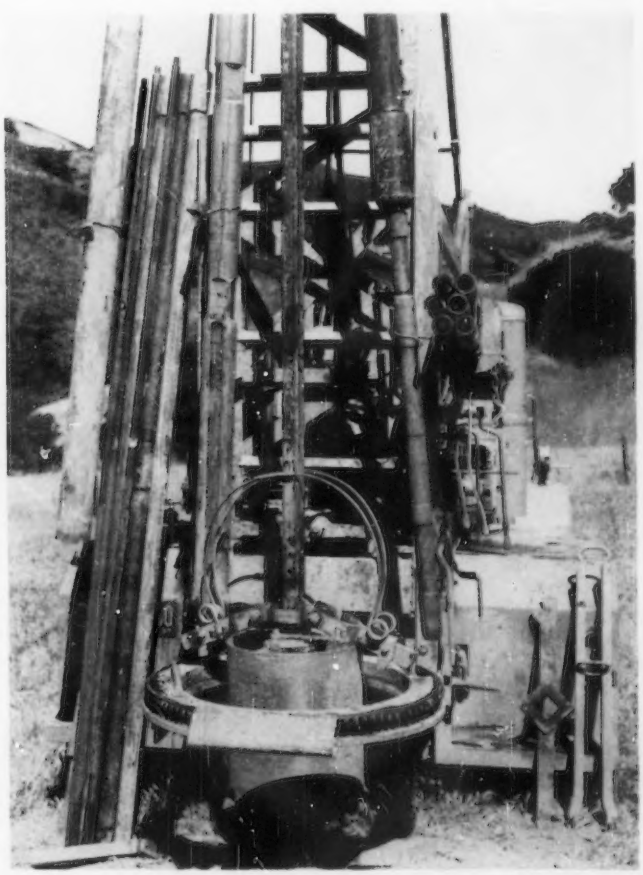

FIG. 2.—Rig, with Tools for Churn Drilling, Rotary Boring, and Soil Sampler for Procuring Undisturbed Cores.

[1] Materials and Research Engineer, California Division of Highways, Sacramento, Calif.

[2] T. E. Stanton, Jr., "An Improved Type of Soil Sampler for Exploration of Soil Conditions and Sampling Operations," *Proceedings*, Internat. Conference on Soil Mechanics and Foundation Engineering, Harvard University, Vol. 1, June, 1936, p. 13.

[3] O. J. Porter, "Drilling Cost Cut by New Rig for Foundation Investigations," *California Highways and Public Works*, Vol. 15, September, 1937, p. 2.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

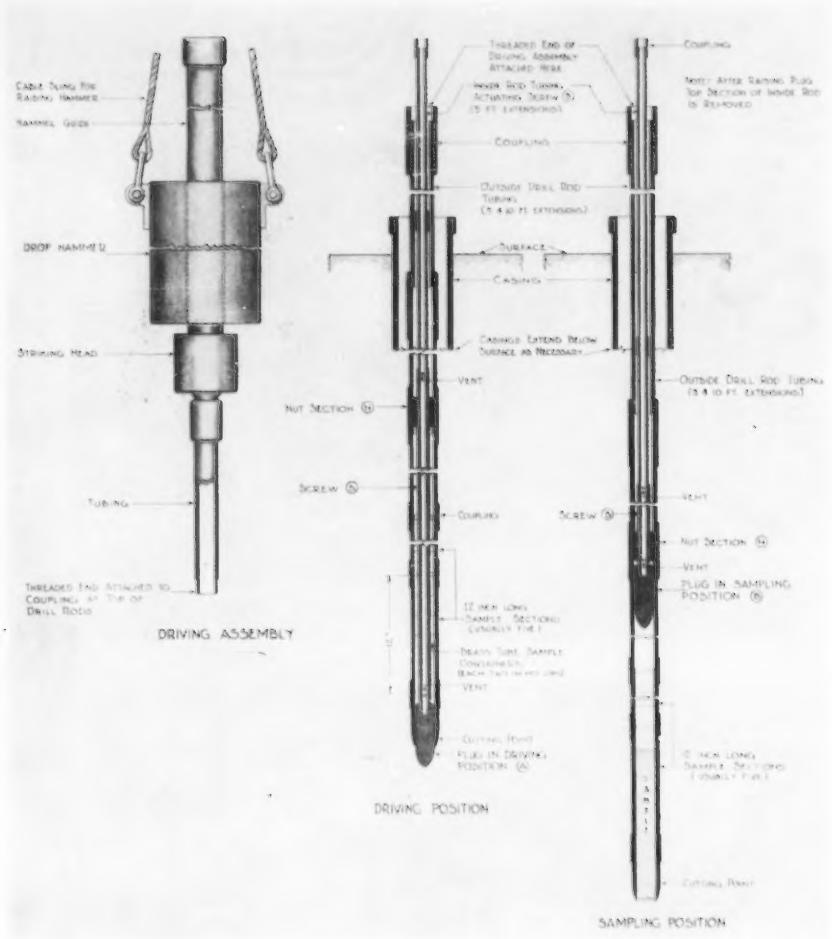

FIG. 3.—Diagrammatic Sketch of Porter Type Soil Sampler.

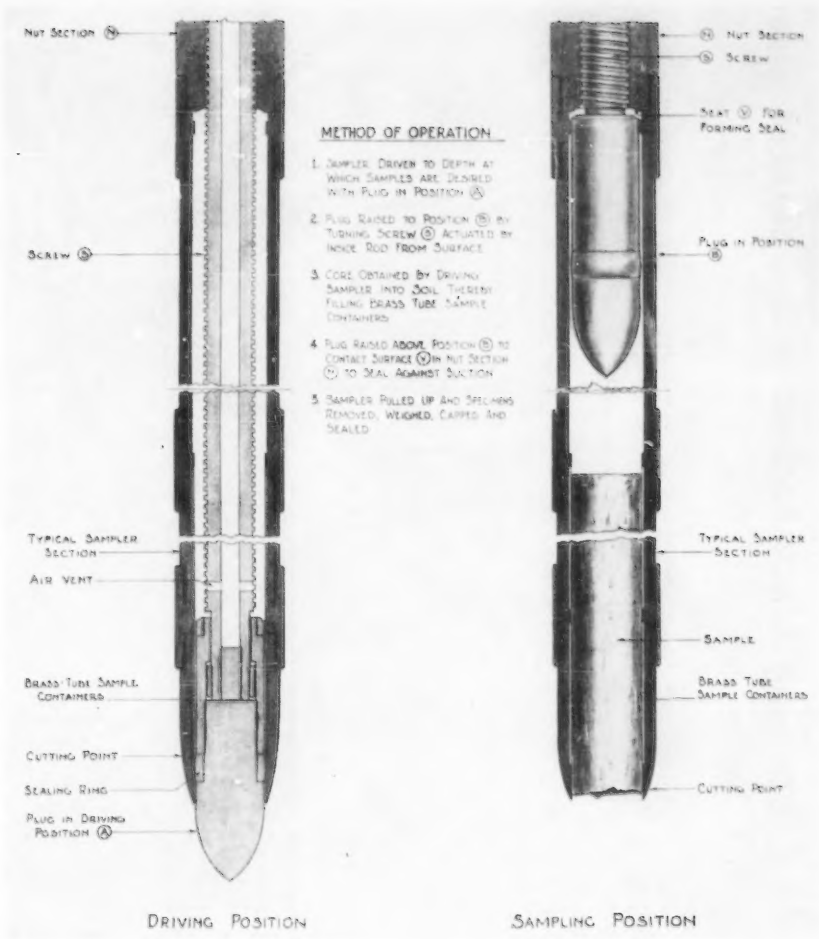

FIG. 4.—Porter Type Soil Sampler.

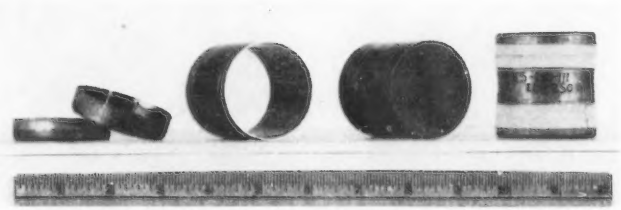

FIG. 5.—Showing Caps, Empty Sample Container, Typical Soil Specimen After Removal from the Sampler and a Typical 2-in. Container and Sample, Sealed and Prepared for Shipment to the Laboratory.

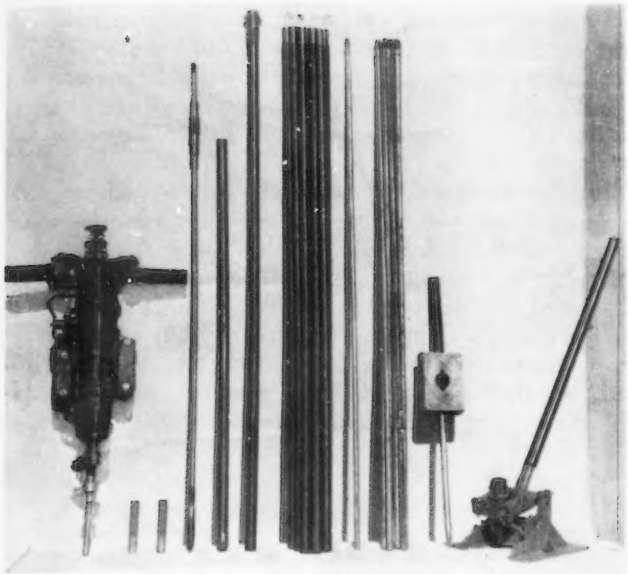

FIG. 6.—Sampler (1 in.) and Equipment for Making Hand Borings to a Depth of 50 ft.

Left to right: Gasoline hammer; two 6-in. sample retainers; plug and nut assembly; sampler with cutting point; ten 5-ft. outside extension rods; ten inside extension rods; drop hammer and jack with pulling grip.

a seal against suction immediately above the top of the sampler. The screw shaft and nut section are provided with a fast pitch, left-hand modified Acme form thread so that the plug may be readily retracted by actuating the inside drill rods in a right-hand direction. The plug is connected to the screw shaft in a manner to permit swivel action.

All sampler parts are made from high-quality nickel or tool steel and connections are made with modified Acme form threads and butted joints within the couplings. The outside extensions from the sampler to the surface consist of standard "P.K." diamond drill rods, except that the couplings are bored out sufficiently to clear the diamond drill "E" rods which are utilized as extensions from the screw shaft to the surface.

OPERATION

Samples are taken by (1) driving the sampler, with the plug in the driving position, to the desired depth; (2) retracting the plug and then driving the open sampler into undisturbed material; (3) retracting the plug further to effect an airtight seal above the sample; (4) rotating the outside drill rods in a right-hand direction to shear off the soil at the bottom of the cutting points and (5) withdrawing the entire sampler unit to the surface.

The string of 2-in. brass sample retainers, with the contained samples, are pushed out of the sampler sections, immediately following removal from the hole, cut into sections at the joints between the retainers with a fine piano wire saw, and then capped and weighed. The unit weight of the cores, together with the examination of the cut surface and the resistance to penetration as determined from the driving record, furnishes an immediate index in the field, as to the uniformity and character of the material. Specimens retained for shipment to the laboratory are at once taped, marked and sealed with paraffin in order to prevent any change in the original condition.

A 3 to 4-ft. length of soil core is normally obtained in one sampling operation. When necessary, practically continuous cores can be secured by driving the plugged sampler to the lower elevation of the previous sample before retracting the plug. On important work one core, 3 to 4 ft. in length, is usually taken for each 5 ft. of depth. In many cases, however, the driving record furnishes sufficient information regarding the uniformity of the material so that drilling opeations can be expedited by taking test samples at less frequent intervals.

Casing is required only when the skin friction becomes too great to permit ready driving and pulling of the sampler. The casing, when necessary, is sunk by jetting or churn drilling methods, to the depth previously sampled. Sampling is then continued below the casing in the usual manner.

When information regarding the probable stability of slopes is required in connection with large cuts through alternate layers of sandstone and soft shale, continuous samples are taken until a hard stratum is encountered. A churn drill is then used through the hard stratum until another soft layer is encountered, after which the tube sampler is again used to secure cores of the questionable material. Thus by alternately sampling and churn drilling, accurate advance information has been obtained at the site of proposed cuts ranging up to 100 ft. or more in depth.

HAND SAMPLER

The hand-operated sampler is used in connection with routine preliminary soil surveys in connection with both highway and bridge projects. The holes are put down in all cases without casing and cores approximately 1 in. in diameter are obtained from penetrable ground to depths of 40 and 50 ft.

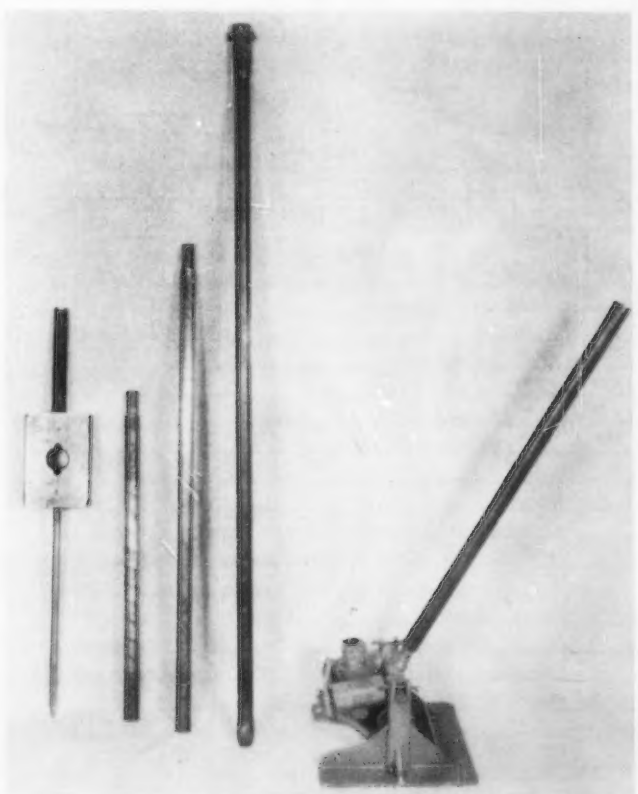

FIG. 7.—Soil Tube Sampler for Boring to a Depth of 8 ft.

Left to right: Drop hammer; 2 and 3-ft. extension rods; sampler with cutting point and driving head; and lever type jack for pulling the sampler from the ground.

Container and Sample, Sealed and Prepared for Shipment to the Laboratory.

About fifteen outfits of this size are in constant use throughout the state.

In most cases when investigating bridge foundations the field crews are usually able to obtain sufficient information with this 1-in. sampler. The driving record, when correlated with the moisture content, unit weight, and character of the soil usually indicates whether piles are necessary and the probable length required. When the hand borings disclose difficult foundation conditions, a complete investigation can readily be made with the larger equipment, particularly if a tentative soil profile, showing the uniformity and extent of the questionable strata, has already been prepared from the hand boring data.

A 2 to 3-ft. length of core, depending upon the type of soil, is usually obtained in one sampling operation. Although these 1-in. cores are not large enough and sufficiently free from disturbance to be suitable for consolidation and shear tests, they furnish reliable information regarding the density, moisture content, texture and structure of the ground.

Figure 6 shows the smaller sampler, extension rods and tools required for making hand borings to a depth of 50 ft. The equipment is operated similarly to the larger sampler. When a considerable number of the borings 10 ft. or more in depth are required a gasoline hammer is often used for driving the equipment.

Routine subgrade surveys are also made with this sampler. Figure 7 shows the sampler, extension tubes and other tools normally used for sampling to a depth of 8 ft. With this equipment it is usually possible for two men to make 75 to 100 borings in one day. The classification and uniformity of the ground is determined from the driving record and a visual examination of the cores. After the materials have been identified and a soil profile prepared, large diameter auger borings are made to obtain adequate samples for testing to determine the relative compaction of the ground and the suitability of the materials for use in subgrade and embankments.

Figure 8 shows the boring record report form used in California together with typical field data for a power boring.

STATE OF CALIFORNIA—DIVISION OF HIGHWAYS
MATERIALS and RESEARCH DEPT.
BORING RECORD

DIST IV CO Napa RT 7 SEC H STA 572+00
LINE A FT. Right Left 10 CONT. NO Prel. S.A. E.W.O. #256

OPERATING CREWS	CONTRACTOR'S	ON	OFF	STATE	ON	OFF
				C.M.S.	8[00]	4[30]
				H.L.F.	"	"
				G.B.C.	"	"

SAMPLING DATA

Sample No.	Sampler	Time Record: Start Down	Raise Plug	Driving Comp'd	Sample Out	Elevation Data: Overall Length	Stick Up	Depth	Elev.	Retained Sample: Elev.	No. Retained: Brass	Jars
D	Cl.	10[00]				26"	0"	26"	413		5	2
	Op.		10[15]	10[25]	10[35]	31"	2"	29"	410		Length Core	36"
E	Cl.	10[20]				31"	2"	29"	410		6	1
	Op.		11[00]	11[10]	11[20]	36"	4"	32"	407		Length Core	36"
F	Cl.	11[30]				36"	2"	34"	405		3	1
	Op.		11[45]	12[00]	12[20]	36"	0"	36"	403		Length Core	24"

Weather Clear
Temp. Warm

REMARKS

Elev. of Water in Hole Dry

8[00] to 12[00] Sampling
12[00] to 12[30] Lunch
12[30] to 1[00] Sampling
1[00] to 2[00] Moving to Boring #3

Legend:
J = Cores removed from brass tube retainers and saved as a jar sample for moisture content and grain size tests.
I, II, III etc. Numbers - Tubes, saved, sealed, and shipped to Laboratory for testing.

Contractor _____ Inspector L.W.

HOURS SPENT TODAY IN: Sampling	Drilling	Casing	Moving	Repairing	Contractor's Pay Time: Today	To Date

Form T-35
10M 6-38

ELEV. Reference 439 Surface 439 Op. Bor. _____
Dia. Sampler 2" Wt. Hammer 450 Today's Sheet No. 2
Page No. 12 Boring No. 2 Date 2-14-39

Depth	ELEV.		Tube	Wt. Per Cu. Ft.	Driv. Rec. Blows per Ft.	Length of Drive	LOG OF MATERIAL
26	413					18"	
			V	93	6		Plastic clay
27	412		J				Old slide material
			IV	91	8		
28	411	2-D	III	92			← Change: Probable surface of old ground
			J				
			II	96	12		Brown clayey topsoil. Roots and
29	410		I	95			vegetation.
			J				
			VI	94	14		
			V	96			← Change:
30	409		IV	117			
			III	118	48		
		2-E	J				
31	408		II	116	52		Stiff brown clay.
			I	115			
32	407						
					48		Plug closed
					50		
34	405						← Change:
			J				
			III	126	260		
35	404	2-F	II	125			Damp brown bedded shale.
			J		325		
			I	127			
36	403						Bottom of Boring

FIG. 8.

Fatigue Tests of Wire

By C. P. Wampler[1] and N. J. Alleman[2]

SYNOPSIS

In many applications the serviceable life of wire is terminated by fatigue failure. Testing machines necessitating a machined specimen do not give a true index of the endurance properties of wire because the effects of surface conditions are removed.

In this paper a method is presented for testing straight wire with the original surface intact and correlation of results, using a bridge wire and a low-carbon steel, is obtained on a second type of testing machine. The two types of wire testing machines are described, also the machine for testing machined specimens.

Results on a low-carbon steel rod and on a brass rod indicate that a tensile set of 0.10 per cent, sufficient to straighten some coiled wire, does not appreciably influence the endurance limit.

SURFACE conditions may appreciably affect the fatigue strength of any structural or machine member. However, the influence of surface finish on the fatigue strength is not determined in the ordinary type of fatigue testing machine in which stress concentration at the grips makes it necessary to use a specimen having a reduced critical section in the length of the specimen where fracture is made to occur; this critical zone would accordingly not include the original surface of the specimen.

Wire represents a structural material used commercially with an unprepared surface and whose serviceable life is in many instances limited by fatigue. Consequently there is a distinct need in the materials testing field for an inexpensive method of testing materials such as wire and rod with a surface condition such as will exist on the member when used in service; this will be referred to as the "as received" condition.

The Krouse rotating-strut machine, embodying the same principles of load application as the Haigh-Robertson wire testing machine[3], developed in England, was used in the tests described in this paper. By applying an end thrust to a rotating wire, the specimen is bent into the form of a column in which the maximum stress occurs on the original surface of the wire at the mid-section; hence, the stress concentration at the grips of the machine does not influence the test results.

The purposes of this investigation were to determine the effect of straightening wire specimens preparatory to testing in the rotating-strut machine; to show the effect of surface conditions upon the fatigue strength of two commercially finished materials; and to check the reliability of the rotating-strut machine by comparing the results obtained with results from another type of fatigue testing machine, using identical materials. Three types of machines were used: (1) the rotating-strut machine, (2) a vibratory (constant-strain) machine, and (3) a high-speed rotating-cantilever-beam machine.

[a] Presented at the Forty-second Annual Meeting, Am. Soc. Testing Mats., Atlantic City, N. J., June 26-30, 1939.

[1] Junior Engineer, A. O. Smith Corp., Milwaukee, Wis. Formerly, Graduate Student, University of Illinois.

[2] Special Research Associate in Engineering Materials, Department of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

[3] E. T. Gill and R. Goodacre, "Some Aspects of the Fatigue Properties of Patented Steel Wire," *Carnegie Scholarship Memoirs*, Iron and Steel Inst. (London) (1936).

DESCRIPTION OF THE ROTATING-STRUT MACHINE

In the rotating-strut machine, Fig. 1, the specimen is loaded as a free-ended column in which the bending stresses are greatest at the point of maximum deflection, the center of the length.

One end of the specimen is gripped in chuck *C* which is directly connected to the motor shaft. The other end of the specimen is held by a sleeve in spherical thrust load bearing *B*, carried by the loading screw *P*. The bearing block *D*, containing the load bearing and the loading screw, may be fixed in any position along the swinging arm *A*, depending upon the specimen length. The swinging arm is pivoted on a vertical axis directly above the face of driving chuck *C* and is counterbalanced by the movable weight *W*.

The specimen is loaded by screwing the load bearing towards the driving chuck. The compressive load causes the specimen to buckle and to swing the arm carrying the load bearing through an angle equal to the angle of deflection of the end of the specimen. The chord of the angle through which the arm swings is measured on the scale *F*, which is fixed relative to the main frame of the machine by arm *E*.

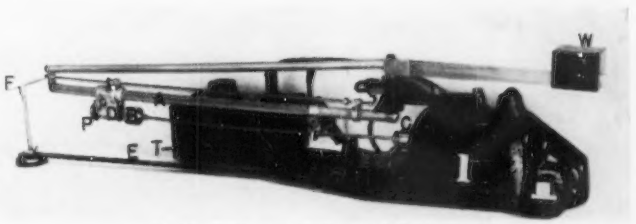

Fig. 1.—Rotating-Strut Machine.

The deflected specimen is caused to rotate about its axis of flexure by the series-wound variable speed a. c. motor, which has a speed range of 2000 to 12,000 r.p.m. Speed control, which is necessary to avoid the critical vibration speeds of the test specimen, is obtained by varying the voltage supplied by the autotransformer *T*. A revolution counter and an automatic stop are attached to the machine.

STRESS CALCULATION

The value of maximum stress in the specimen used in the rotating-strut machine is obtained by considering the specimen to be a long column for which the Euler column formula may be used. This formula assumes a sinusoidal flexural curve for the specimen with zero bending moment at the ends. The maximum stress occurs at the center of the specimen and is calculated from the equation

$$\theta = 360\, S\, L/\pi^2\, E\, d$$

where θ = the angle, in degrees, between the axis of the unstressed specimen and a line between the load point and the chuck face of the stressed specimen,

S = the maximum unit stress in the specimen at the center of the span length, in pounds per square inch,

L = the active length of the specimen between pivots, in inches,
d = the diameter of the test specimen in inches, and
E = the modulus of elasticity, in pounds per square inch.

For computations of θ the chord of the angle is read on the scale to $\frac{1}{4}$ in., making θ accurate to 2 min. of a degree. In the derivation of the formula, θ is substituted for tan θ. At a stress of 58,000 psi. θ is 7 deg. and 17 min. The substitution gives a stress value low by 0.54 per cent. In addition a small compressive stress acts on the specimen. Although negligible, the error tends to balance the error involving tan θ.

DESCRIPTION OF THE VIBRATORY (CONSTANT-STRAIN) MACHINE

The machine shown in Fig. 2 is used to give completely reversed bending in one plane to wire specimens in which the maximum stress occurs on the original surface of the material.

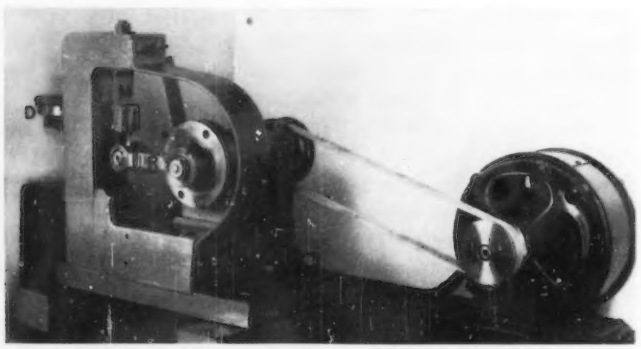

Fig. 2.—Vibratory (Constant-Strain) Machine.

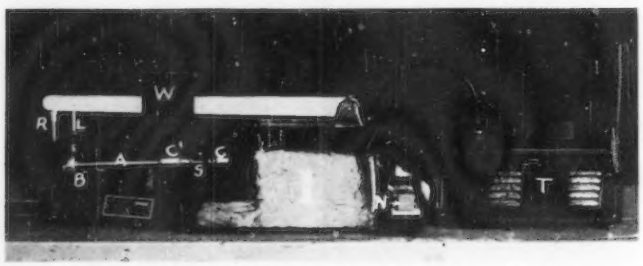

Fig. 3.—High-Speed Rotating-Cantilever-Beam Machine.

The specimen is fastened rigidly to the calibrated spring M, and the load is applied through the free end of the specimen by the connecting rod R, actuated by the variable-throw crank C. Dial gage D measures the deflection of the calibrated spring from which the load applied perpendicular to the longitudinal axis of the specimen at the load line may be obtained. The significant bending moment on the specimen is calculated from the load and the distance of the critical section from point of application of the load.

The load on the specimen is varied by changing the throw on the crank C. The range of stress is varied by moving the casting holding the crank and crankshaft in relation to the frame holding the spring. This movement is controlled by two setscrews. A completely reversed cycle of stress was used in the tests described in this paper.

DESCRIPTION OF THE HIGH-SPEED ROTATING-CANTILEVER-BEAM MACHINE

The high-speed rotating-cantilever-beam machine (Fig. 3) is the wire machine with the wire testing adapters and arms replaced by an arm A carrying a chuck C' at one end and a bearing B at the outer end. The scale beam, graduated in inch-pounds of bending moment on the specimen S and carrying the weight W, is pivoted at one end on top of the motor housing. Load is applied to bearing B by the rubber tipped leg L. Rod R operates the automatic stop in the base of the machine.

MATERIALS AND TEST SPECIMENS

The materials used in the various fatigue tests are as follows: S.A.E. No. 1020, $\frac{1}{8}$-in. diameter cold-drawn steel rod; S.A.E. No. 1020, $\frac{3}{8}$-in. diameter cold-drawn steel rod; cold-drawn 80-20 brass rod, $\frac{1}{8}$-in. diameter; and high-carbon steel wire, heat treated and galvanized, 0.195 in. in diameter.

For the rotating-strut machine, the specimens were approximately 100 diameters in length, the ratio of length to radius of gyration (L/r) for all tests was over 400, well within the range of applicability of Euler's column formula. Adapters, $\frac{1}{4}$ in. in outside diameter to fit the machine grips, were pressed onto the ends of each specimen.

In order to compare the results obtained on the rotating-strut machine and those obtained on the vibratory machine, it was necessary to have the maximum stress in the vibratory machine specimens occur on the original surface of the material at a section outside the stress-raising influence of the machine grips. To accomplish this condition, the wire test specimens were reduced in width to 0.050 in. at a section in the length between the grips so as to have a minimum cross-section nearly rectangular in shape, the shorter sides of this section being arcs of the original surface material. The specimens were placed in the grips of the machine in such a manner that the maximum bending stress occurred on the original surface. The maximum stress on the specimen is calculated from the flexure formula, assuming the minimum section to be rectangular—the error introduced by this assumption is very small.

TABLE I.—RESULTS OF STATIC TENSION TESTS.

	Tensile Strength, psi.	Yield Strength, psi.	Elongation in 10 in., per cent	Reduction of Area, per cent	Modulus of Elasticity, psi.[a]
S. A. E. No. 1020, $\frac{3}{8}$-in., cold drawn	101 000	91 000	15.5	44	30 000 000
S. A. E. No. 1020, $\frac{1}{8}$-in., cold drawn	116 000	108 000	11.0	39	30 000 000
Bridge wire[b]	223 000	189 800	6.1[c]	37	29 400 000
Brass Rod, $\frac{1}{8}$-in., cold drawn	72 000	52 000	7.2	51	13 000 000

[a] Average values.
[b] W. H. Swanger and G. F. Wohlgemuth, "Broken Loops", *Metal Progress*, Vol. 30, August, 1936, pp. 59-67.
[c] 2-in. gage length.

A high-speed rotating-beam machine was used to obtain the endurance limits on machined and polished specimens of the S.A.E. No. 1020, $\frac{3}{8}$-in. diameter steel rod and of the heat-treated steel wire. Specimens for this machine, 2 in. in length, were turned by a tool swung on a $1\frac{1}{2}$-in. radius to a minimum diameter at the center of 0.10 in. The surface of these specimens was carefully polished to remove all circumferential scratches.

TEST METHODS

Tension tests were made on all materials to obtain values of tensile strength, yield strength corresponding to 0.10 per

cent offset[4], and modulus of elasticity. Table I gives these data.

The following fatigue tests were made:

Series 1.—Tests on the $\frac{1}{8}$-in. diameter brass and the $\frac{1}{8}$-in. diameter S.A.E. No. 1020 steel rod to determine the effect on the fatigue strength of giving the materials a permanent tensile deformation of 0.10 per cent. The endurance limits were

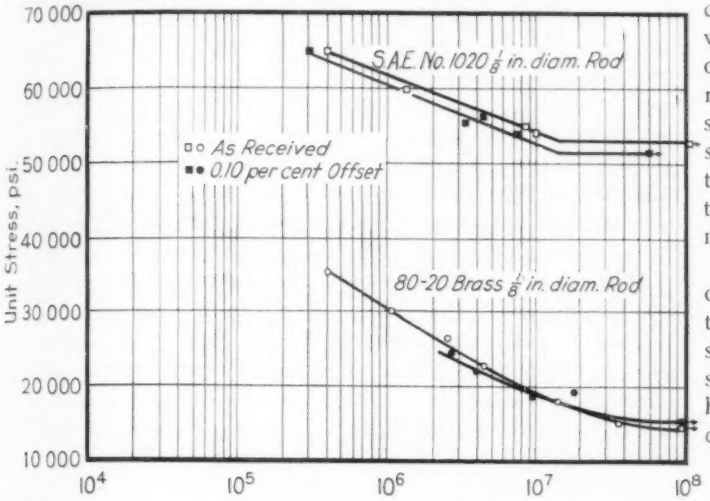

Fig. 4.—Showing the Effect of a Unit Deformation of 0.10 per cent on the Fatigue Properties of Cold-Drawn Steel and Brass Rods.

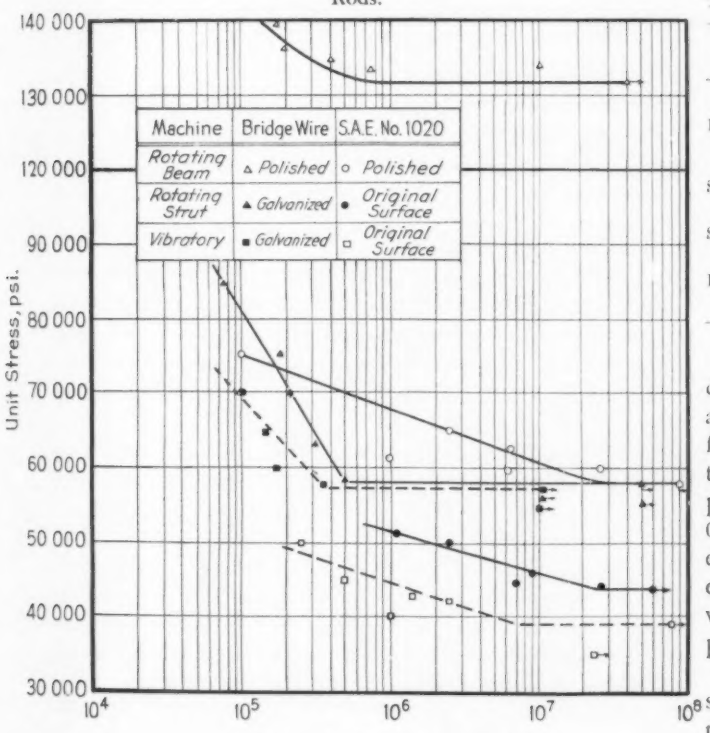

Fig. 5.—Showing the Effect of Surface Condition on the Fatigue Properties of a High-Carbon Steel Wire and a S.A.E. No. 1020 Cold-Drawn Rod.

obtained first on specimens cut from the original rods and then on similar specimens that had been given a 0.10 per cent tensile permanent deformation or set. A tensile set of 0.10 per cent is sufficient to straighten wire or rod which is initially curved.

Series 2.—The high-carbon heat-treated steel wire and the S.A.E. No. 1020, $\frac{7}{16}$-in. diameter steel rod were used in this series of tests to determine the effect of surface conditions upon the fatigue strengths of the materials. The high-carbon steel wire, which was taken from a coil and hence had some curvature, was straightened by tensile loading to the stress which caused the material to retain a permanent deformation of 0.10 per cent. Specimens of the S.A.E. No. 1020 steel rod were made from the material as received. The fatigue strengths of both materials were established in the rotating-strut machine with the original surface of the specimen intact; the fatigue strengths were also found for specimens with turned and polished surfaces by means of the rotating-beam machine.

Series 3.—In order to compare fatigue strengths obtained on the different machines, tests were made in the vibratory type machine using the same materials as were used in series 2. As already noted, in this machine, the maximum stress occurred on the original surface of the materials, and hence the results of fatigue strengths might be expected to be comparable with those found in the rotating-strut machine.

TEST RESULTS

The curves of Figs. 4 and 5 show the results obtained in the various tests, a summary is given in Table II. It is evident that the straightening of the S.A.E. No. 1020 steel rod and the 80-20 brass rod had no pronounced effect upon the fatigue strengths of the materials. The endurance limit of the S.A.E. No. 1020 steel rod as received, Fig. 4, was 53,000 psi. while that of the same material which had been given a 0.10 per cent tension elongation was 52,000 psi. This difference is no greater than the probable experimental error. The endurance limits of the brass rod in the as received condition was 15,000 psi. and after being given a tensile set of 0.10 per cent was 16,000 psi.

TABLE II.—RESULTS OF REPEATED-STRESS (FATIGUE) TESTS.

	Diameter, in.	Surface Condition	Endurance Limit, psi.	Testing Machine
Bridge wire....	0.195	Galvanized[a]	58 000	Rotating strut
		Galvanized[a]	57 000	Vibratory
		Machined	132 000	Rotating beam
S.A.E. No. 1020	$\frac{7}{16}$	Cold-drawn	43 000	Rotating strut
		Cold-drawn	38 000	Vibratory
		Machined	58 000	Rotating beam
S.A.E. No. 1020	$\frac{1}{8}$	Cold-drawn	53 000	Rotating strut
		Cold-drawn[a]	52 000	Rotating strut
Brass.....	$\frac{1}{8}$	Cold-drawn	15 000	Rotating strut
		Cold-drawn[a]	16 000	Rotating strut

[a] Material given a tensile set of 0.10 per cent.

It may be concluded from the results obtained in the above series of tests that the small amount of tensile elongation had no measurable effect upon the fatigue strength of the materials. The results listed here have a limited application, and more extensive research will be required to determine definitely what effect straightening has on high elastic strength materials.

The effect of surface condition upon the fatigue strengths of the heat-treated high-carbon steel wire and the S.A.E. No. 1020, $\frac{7}{16}$-in. rod are shown by the curves of Fig. 5. The fatigue strength of the heat-treated wire as tested in the rotating-beam machine, using carefully machined and pol-

[4] Standard Methods of Tension Testing of Metallic Materials (E 8 – 36), 1936 Book of A.S.T.M. Standards, Part I, p. 833.

ished specimens, was 132,000 psi. The same wire tested in the rotating-strut machine with the original galvanized surface intact had an endurance limit of 58,000 psi. In calculating the stress on the galvanized specimens the protective coating was considered as having zero thickness, that is, the specimen diameter was taken as the diameter of the wire with the zinc coating removed. Taking the value of the endurance limit obtained on polished specimens in the rotating-beam machine as a basis, there was a 56 per cent decrease in fatigue strength due to the surface defects of the material.

The photomicrograph of Fig. 6 clearly shows a deep pit and slight surface decarburization in the material. The low value for fatigue strength obtained is not unusual considering the stress concentration due to pits and the weakening effect of the ferrite grains. From Fig. 6 it will be noted that the decarburization follows the surface pit and extends into the parent metal of the wire, a condition very poor from the

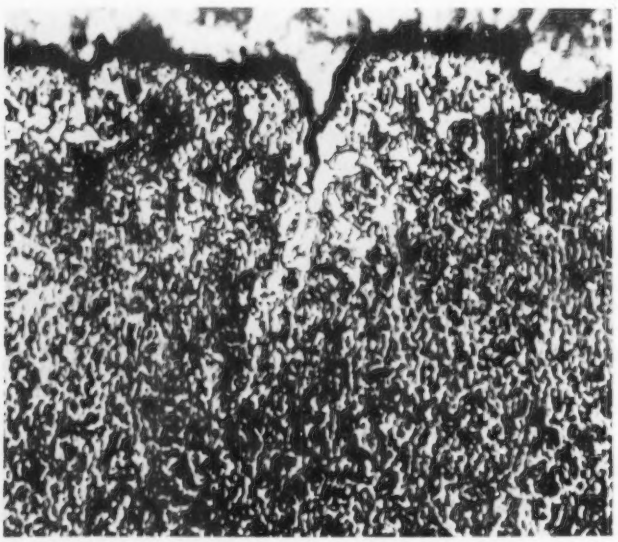

Fig. 6.—Photomicrograph of Galvanized Heat-Treated Bridge Wire Showing Surface Decarburization (X 500).
Transverse specimen, etched in Nital.

fatigue standpoint. The dark band next to the parent metal probably represents a hard and brittle zinc-iron compound often found in hot-dipped galvanized steel. This hard material, weak in fatigue, is situated in the region of maximum stress, and a crack forming there progresses into the soft grains which have a low resistance to the spread of a crack. Further progress of the fracture leads to fatigue failure, since the heat-treated parent metal has a rather high degree of notch sensitivity, or a low resistance to the propagation of a crack. The combination of sharp surface discontinuities, a galvanized surface, surface decarburization, and a notch sensitive material are adequate explanation for the low endurance limit of the high-carbon heat-treated steel wire.

The weakening effect of surface defects is again shown by the results obtained in tests of the S.A.E. No. 1020, $\frac{7}{16}$-in. steel rod. The fatigue strength as determined in the rotating-strut machine was 43,000 psi. as compared to 58,000 psi. for the polished specimens tested in the rotating-beam machine. These figures represent a decrease in fatigue strength of 26 per cent due to surface condition. The cold-drawn rod presents a very much better surface from the fatigue standpoint than does the galvanized wire, since the test results for this rod show much less reduction in the endurance limit due to the surface condition than was found for the heat-treated high-carbon galvanized wire. The photomicrographs of the cold-drawn rod, which are not shown, indicated a normal structure with no pronounced surface discontinuities or decarburization.

The results of the above tests are in agreement with work done on similar materials at the National Bureau of Standards by Shelton and Swanger[5]. One of the materials they used was identically the same high-carbon heat-treated galvanized steel wire that was used in the tests herein reported.

Referring to the curves of Fig. 5, it can be seen that a close agreement of results was obtained by testing the high-carbon steel wire and the S.A.E. No. 1020 rod in the rotating-strut machine and in the vibratory type machine. The fatigue strength for the high-carbon wire is nearly the same as determined in the two machines. The fatigue limit of the cold-drawn rod was 5000 psi. lower as found from tests in the vibratory type machine. This decrease in fatigue strength may possibly be attributed to stress concentration at the sharp corners of the specimens. The high-carbon wire specimens were polished and the corners rounded off; but since this made it difficult to determine the thickness, the specimens from the cold-drawn rod were used with sides and sharp edges of the machined surfaces unpolished. In dealing with the bending of a rectangular beam, the corner is usually not considered as a stress raiser, but at a sharp, or rough, corner there is a stress concentration which does affect the fatigue results.

SUMMARY

1. The rotating-strut machine offers a convenient and relatively inexpensive means of testing wire or rod in diameters from $\frac{1}{16}$ to $\frac{7}{16}$ in. without removing the original surface of the wire or rod. The comparable results obtained on the rotating-strut machine and the vibratory type machine indicate that the methods of load application and stress calculation used for the rotating-strut machine are reliable.

2. The surface condition of the wire tested had a pronounced influence in reducing the fatigue strength below that found by testing specimens which had a carefully machined and polished surface.

3. Straightening of the brass and soft steel rod by giving the rod a permanent elongation of 0.10 per cent had no appreciable effect upon the fatigue strength of the materials and showed that these materials can be straightened for test in the rotating-strut machine without measurably influencing the results obtained.

Acknowledgment:

The investigation described in this paper was a part of a thesis carried out by the first named author under the direction of N. J. Alleman. During the progress of the work the authors received valuable suggestions and criticism from Profs. H. F. Moore and F. B. Seely.

[5] S. M. Shelton and W. H. Swanger, "Fatigue Properties of Steel Wire," *Journal of Research*, Nat. Bureau Standards, Vol. 14, January, 1935, pp. 17-32.

DISCUSSION

MR. A. V. DE FOREST.[1]—I think it is very fortunate that people are willing to correlate the rotating beam strut machines with the more conventional bending type and the longitudinal uniform loaded pulsating stress, because we have in the wire a very difficult problem of fatigue testing, and the more different types of wire that can be tested in different ways, the more the limitations of different methods will appear and we will know what precautions are necessary for hard wire as compared with soft wire. I take it that most people who have had experience with soft wire in a rotating-beam machine have found that it was satisfactory. With the harder wires and particularly the rope wire type, the difficulties are much greater.

With reference to the vibrating tests shown, I should like to ask whether a clamp cannot be used in which the wire is clamped close to the neutral axis and the crack is started in the free surface between the edges of the rectangular clamp. We found that method of clamp to work on both soft and hard wire without starting the fatigue crack at the clamping point. I believe it is highly important to examine all fatigue failures and to be perfectly certain that the point at which the fatigue failure starts is not involved in the stress raising conditions due to the clamp or due to a local defect in the wire. If we are looking for the weakest possible point in a piece of wire of many feet in length, quite evidently the vibrating test is not the one to use. I think the strut plan with Swanger's long-length specimen as used on the bridge wire was the best. Fatigue testing a mile of wire is not so simple. If we are looking for that, we do not know how to do it.

MR. N. J. ALLEMAN.[2]—If Mr. de Forest's clamping device proves feasible it should be a boon to fatigue workers because clamping difficulty is the greatest obstacle encountered when attempts are made to obtain fatigue properties influenced by surface defects, commercial finishes, etc.

We believe that the Krouse machine has several points of superiority over the long-span machine, namely, price consideration, ease of inserting specimens, and ready adaptability to various lengths of specimens.

MR. H. F. MOORE[3] (*by letter*).—Some time ago in the Fatigue of Metals Laboratory of the University of Illinois, tests of a heat-treated chromium-vanadium steel were run under alternating flexure in a vibratory type fatigue testing machine. Tests were run with unreduced round pieces, and with round pieces reduced at the critical section. The nonreduced specimens were held in V-grips as described by Mr. de Forest. The fracture of the nonreduced specimens did not start at the point of contact with the grips, but at the extreme fiber. However, the endurance limit for the nonreduced specimens was about 13 per cent lower than that for the reduced specimens.

MR. E. E. THUM.[4]—I want to inquire as to the meaning of some items in Fig. 5. Apparently there is no direct comparison between the rotating-beam machine and the rotating strut machine, because the materials which were rotated were different in each case. The author has verified that supposition.

Then I would go another step and assume that both machines are reasonably correct and are giving a true measure of the effect of galvanizing on heat-treated bridge wire. This is to reduce the endurance limit from something over 130,000 psi. to something less than 60,000 psi., which is roughly one-half. Do the authors agree?

MR. ALLEMAN.—A clarification of terms is necessary in answering Mr. Thum's question. The term hot-dip galvanizing includes the process of pickling which appears to have more influence on the endurance limit than does the mere presence of the zinc coating. Wire stripped of the zinc coating showed an endurance limit of 59,000 psi. indicating that the reduction in fatigue strength from 132,000 psi. may be due to: (1) surface imperfections in the heat-treated wire, (2) enlarging and deepening of the imperfections in the pickling bath, and (3) the presence of the zinc coating with its inner layer of iron-zinc compound.

MR. THUM.—That may be a distinction without a difference. If the surface was good before galvanizing and is bad after galvanizing, it is rather difficult for me to understand how else the difference came about. Some of the National Bureau of Standards' investigations indicated that galvanizing decreased the endurance limit considerably. Nevertheless, I also believe that cold-drawn bridge wire is still galvanized. I wonder if Mr. Moisseiff could give us some ideas as to the bridge engineer's feelings about the practical influence of these endurance tests on design, or as to the utility of the galvanized material in a bridge which justifies its continued use.

MR. LEON S. MOISSEIFF.[5]—The paper presented by the authors is a valuable study of wire as used. Bridge engineers are not much concerned about vibration of wires in the cables of suspension bridges. The record of bridge wire in cables is clear in this respect. Cable wires do not vibrate in the ordinary sense. Engineers are, however, much interested in the galvanizing of bridge wire for bridge cables as protection against corrosion.

The old Brooklyn Bridge, built in the seventies and opened in 1881, has galvanized wire. Its cables have shown no deterioration after sixty years of existence. The first long-span suspension bridge built after the Brooklyn Bridge was the Williamsburg Bridge over the East River in New York City. It was completed in 1903, and is the only long-span bridge in this country which has "bright," non-galvanized wire in its cables. I do not know why the wire was not galvanized but evidently it was thought not necessary to do so. Probably because the wire in the Brooklyn Bridge had behaved so well and the ungalvanized wire was cheaper to make and the strength specifications could more easily be met. Whatever the reasons, the wire was not galvanized; it was painted with lead and protected by steel plate enclosures wrapped with canvas. After about ten years this protection was found to be inadequate; it was removed and the cable was wrapped with wire in the usual manner. Since then, no further indications of corrosion were found.

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[4] Editor, *Metal Progress*, American Society for Metals, Cleveland, Ohio.

[5] Consulting Engineer, New York City.

About five years ago, it was discovered that what appeared soundly protected was not so. Where the cables were wrapped into units no indications of rust show. When entering into the anchorages the cables, however, deploy into their constituent strands and pass over the strand shoes. Here the individual wires become exposed to the atmosphere. In the bridge these wires were always thoroughly covered with lead paint which is the standard paint for New York City bridges. Indeed, the wires in all these years were so well painted and repainted that the individual wires were covered with a coat resembling Cordova leather. It happened that the paint was taken off some of these wires and it was found that quite a few wires were thoroughly rusted under the paint; some wires looked more square than round. This occurred at one end of one of the four cables of the bridge. It was established that a comfort station was located on the anchorage at the level of the promenade and that during a number of years rain water and slops leaked into the anchorage just above the exposed wires. The cables were not especially protected by a shed. Evidently water containing uric acid came on some of the exposed wires and was active under the paint coat.

The condition was remedied by cutting out the rusted wires and splicing in new wires under tension. The story is told here because it presents a striking example. Recently, what may be called a minor bridge in one of the central states, has shown serious deterioration by rust. In this bridge also the cable wires were not galvanized. So serious was the deterioration in this case that the cables of this bridge will be removed entirely and replaced by new galvanized wire cables.

Bridge engineers have found that hot galvanizing has proved to be a very efficient protective coating. True enough, we do know that the galvanizing bites into the material and penetrates into the surface cracks of the wire, as is well shown in the authors' photomicrograph, and we would like to have a coating equally effective without the disadvantages of hot galvanizing. Galvanized wire may show less fatigue strength and have some other troubles, but until a protective coating is developed that does not have the drawbacks of galvanizing and is as efficient against rust corrosion, bridge engineers will be inclined to adhere to hot galvanizing.

It should be mentioned here that hot galvanizing produces an annealing effect which results in higher elongation. While the elongation of "bright" wire is around 2 per cent, that of hot-galvanized wire is 5 per cent and over. This increase in elongation is of great importance in a material so "short" in behavior. As far as the cold-drawn bridge wire itself is concerned, we have had no trouble whatever with its physical behavior. It is the most dependable element in bridge construction.

MR. H. J. GODFREY.[6]—For the past few months we have been studying the fatigue properties of cold-drawn steel wire. The investigation was designed primarily to establish the relationship between the fatigue limit stress of cold-drawn wire and the tensile strength.

The materials tested include wires of various carbon contents ranging from 0.05 to 0.90 per cent. The wire has been tested in the patented condition and in various stages of cold drawing from zero to 90 per cent reduction. The fatigue tests were made on a rotating strut machine designed on the same principle as the Haigh-Robertson wire testing machine, developed in England.

The results to date show that the ratio between the fatigue limit stress and the tensile strength decreases with an increase in carbon content. The fatigue limit stress for a 0.05 per cent carbon wire was approximately 47 per cent of the tensile strength; 42 per cent for a 0.12 per cent carbon wire, 35 per cent for a 0.35 per cent carbon wire and 32 per cent for a 0.60 per cent carbon wire. The fatigue limit for the 0.90 per cent carbon wire was also about 32 per cent of the tensile strength. Metallographic studies show little or no decarburization on the surface of the high-carbon material. The resulting lower fatigue limit ratio for the higher carbon content wires may be due to surface conditions, as we know that surface flaws will have more effect on the higher carbon material. We have also found that as the percentage of cold working by wire drawing is increased, the fatigue limit stress increases in direct proportion to the tensile strength. However, after a certain amount of cold work the wire becomes overdrawn and the fatigue limit stress is lower than would be expected. The point where the wire is overdrawn has not been established definitely but further study is being made on this subject.

MR. ALLEMAN.—I wish to thank Mr. Moisseiff for his comments from the standpoint of the bridge engineer.

In regard to Mr. Godfrey's results showing that endurance limit – tensile strength ratio decreases with increased carbon content I want to add that these results are in line with tests run at the University of Illinois on notched specimens.

On severely overstrained rail steel (0.75 per cent carbon) tensile strength increases of the order of 15 per cent were noted, whereas the fatigue strengths decreased approximately 36 per cent, making the endurance limit tensile strength ratio 0.45 per cent for the unstrained steel and 0.26 per cent for the overstrained steel.

Color Tolerances Symposium Published

THE Symposium on Color Tolerances held at the Eighth Annual Meeting of the Inter-Society Color Council has recently been published in the form of a reprint from the *American Journal of Psychology*, under the joint sponsorship of the American Psychological Association.

This pamphlet comprises six technical papers covering the following subjects: psychophysics of color tolerance, ratio method in the review of the Munsell colors, color tolerances as affected by changes in composition and intensity of illumination and reflectance of background, representation of color tolerance on the chromaticity diagram, specification of color tolerances at the National Bureau of Standards, and industrial color tolerances. Each of the papers was prepared by an outstanding authority in the particular field.

Copies of this symposium can be obtained at 50 cents each from Inter-Society Color Council, P. O. Box 155, Benjamin Franklin Station, Washington, D. C.

[6] Engineer of Tests, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.

Stress-Strain-Time Characteristics of Materials[a]

By Glenn Murphy[1]

SYNOPSIS

This paper describes a method for presenting on a single diagram the stress-strain relationships for varying rates of loading, the strain-time relationships for varying stresses, and the stress-time relationships for varying strain, thus giving an indication of the behavior of a material under any combination of stress, strain or time. Properties of a material, such as elastic strength, ultimate strength, resistance to impact loading, and creep limit for various amounts of total deformation, also may be evaluated from the characteristics of the diagram which is the surface developed by plotting along the three coordinate axes values of stress, strain, and time from loading tests on the material.

Description of the surface developed from tests on lead is given, together with a discussion of the determination of the properties from the diagram.

THE usefulness of a material for a given purpose may be predicted only when the behavior of the material may be foreseen under the specific conditions to which it will be subjected in use. To aid in the prediction of the probable behavior, a number of properties have been defined for evaluating the degree of presence of mechanical characteristics. Each property is defined in such a way that it will give a measure of some characteristic of the material under specific conditions. If all necessary properties of a material were evaluated, it should be possible to predict the behavior of the material under any combination of circumstances.

Many of the properties are expressed in terms of stress since, in most cases, design is based upon stress as the critical factor. That is, if the stress is less than a specific value, the magnitude of which depends upon the conditions of usage, it is assumed that the material will function properly, and if the stress exceeds that value, failure may result. However, increasing attention is being given to the importance of strain, both as a criterion of failure and as an indication of the mechanism of failure of materials, with the result that the stress-strain relationships are regarded as giving essential information concerning the characteristics of materials.

Where service conditions agree with the conditions under which the laboratory tests are made, the laboratory tests provide a reliable basis for design. For example, if the loads on a member in service are applied gradually and at normal temperatures, the behavior of the material may be expected to agree, within limits depending on the uniformity of the material itself, with the conventional short-time test carried out under ordinary laboratory conditions.

However, experience has clearly indicated that the results obtained from ordinary short-time laboratory tests cannot be extrapolated safely to meet other conditions. A variation in temperature may greatly alter the stress-strain relationships of a material. Another very important factor is the length of time during which the load is applied. A suddenly-applied load, or a load left on a member for many months may produce decidedly different effects than a load applied over a period of a few minutes, as impact and creep tests have amply demonstrated. In other words, the stress developed in a material at any time is directly related to the strain, time of loading, and temperature.

Since a single stress-strain diagram or any similar plane curve cannot depict the differences in the characteristics of a material resulting from variation in both strain and time of loading, a clearer conception of the interrelationships of stress, strain, and time may be derived by constructing a three-dimensional diagram which will show the effect of the time of loading upon the stress-strain behavior of a material. In many cases stress, strain, time, and temperature all enter into the evaluation of the action of the material, but in the following discussion the temperature will be assumed to remain constant, and the relationships between stress, strain, and time will be considered.

CONSTRUCTION OF DIAGRAM

The interrelationships of stress, strain, and time for a material under axial load or pure shear may be shown conveniently by plotting along the three coordinate axes values of the time, strain, and stress as determined from tests.[2] Stress and strain are measured from the initial unloaded condition of the material and time is measured from the beginning of the application of the stress or strain. If the results obtained from a number of tests in which different rates of loading are used, the plotted points will define a surface. Any point on the surface will indicate the coexistent values of stress, strain, and time. The existence of such a surface is dependent upon the assumption that the stress developed in a member at a given temperature is dependent only upon the strain and the time of loading, or else upon the assumption that the strain developed is dependent only upon the stress and the time. Which of the two assumptions is involved depends upon whether stress or strain is considered to be the dependent variable. The interrelations between stress and strain for various materials have been recognized for some time, and the existence of definite relationships between strain and time under different stresses is well established by numerous creep tests. Therefore, the assumption of definite relationships between stress, strain, and time within reasonable limits of accuracy seems to be justified. In effect, the validity of the assumption rests upon the validity of the theory of superposition—that the stress developed is the sum of the stress developed by the strain effect and the stress developed by the time effect.

From the mathematical viewpoint, the dependence of the stress upon the strain and the time may be written as

$$dS = \frac{\partial S}{\partial \varepsilon} d\varepsilon + \frac{\partial S}{\partial t} dt \quad \ldots\ldots\ldots\ldots (1)$$
$$= \varphi d\varepsilon + \psi dt$$

in which S is the stress, ε is the strain, and t is the time, $\varphi = \frac{\partial S}{\partial \varepsilon}$ and $\psi = \frac{\partial S}{\partial t}$. The functions φ and ψ will depend

[a] Presented at the Forty-second Annual Meeting, Am. Soc. Testing Mats., Atlantic City, N. J., June 26-30, 1939.

[1] Associate Professor of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa.

[2] The construction of a somewhat similar diagram, using stress, strain, and rate of strain as the variables, has been discussed by A. Nadai, "The Influence of Time upon Creep," S. Timoshenko, Sixtieth Anniversary Volume, The MacMillan Co., New York City (1938).

upon the type of material under consideration.

$$\text{If } \frac{\partial \varphi}{\partial t} = \frac{\partial \psi}{\partial \varepsilon} \quad \ldots\ldots (2)$$

the stress function,

$$S = f(\varepsilon, t) \text{ or } F(S, \varepsilon, t) = 0$$

defining the surface, exists in finite form.

As a simple illustration, if the stress is below the proportional limit, and the modulus of elasticity of the material is independent of the rate of loading, Eq. 2 is satisfied.

$$\varphi = \frac{\partial S}{\partial \varepsilon} = E = \text{Young's modulus}$$

$$\psi = \frac{\partial S}{\partial t} = 0$$

and Eq. 1 becomes

$$dS = E d\varepsilon$$

which integrates to

$$S = E\varepsilon + C$$

If $S = 0$ when $\varepsilon = 0$, then $C = 0$ and

$$S = E\varepsilon$$

This is the stress function of the material under the assumed conditions and expresses the relationship existing between stress, strain, and time. In this case stress is proportional to strain and is independent of time as was assumed. In the general case where plastic action is occurring, the stress functions φ and ψ will be more complex.

From the geometrical viewpoint, the equation $S = E\epsilon$ is the equation of a plane containing the t axis and having a slope of E with respect to the ϵ axis. The plane will define values of S for any value of ϵ and t. The stress-strain-time curve for any sequence of stress or strain will lie in that plane as long as the assumed conditions of behavior are not violated. For more complex types of behavior involving plastic action, some advantage may be gained by dividing ϵ into two components—one component proportional to stress, and the other component taking into account the non-proportional, or plastic, deformation.

PROPERTIES OF DIAGRAM

Figure 1 shows an example of a diagram for a material[3] under tensile load at ordinary temperatures. The diagram is constructed with time plotted in the x-direction, strain in the y-direction, and stress vertically in the z-direction. The curved surface is the stress surface for the material, any point on the surface giving the simultaneous values of stress, strain, and time. The record of any test will be shown as a line lying on the surface, as OA for example.

The projection of the line on the surface on to the stress-strain plane (the y-z plane) will give the stress-strain relationship (OB) under the conditions of the test. The projection will be the same as the stress-strain diagram obtained without regard to time. The area under the stress-strain diagram up to any stress will be a measure of the strain-energy absorbed within the gage length in developing the stress.

The projection of any line on the surface upon the strain-time plane (the horizontal plane) will give the strain-time relationship (OC) for the material under the given conditions, and the projection upon the stress-time plane (the x-z plane) will give the stress-time relationship.

[3] Based on the data for lead as given by H. F. Moore, B. B. Betty, and C. W. Dollins, "The Creep and Fracture of Lead and Lead Alloys," *Bulletin No. 272*, and *Bulletin No. 306*, University of Illinois, Engineering Experiment Station (1935 and 1938, respectively).

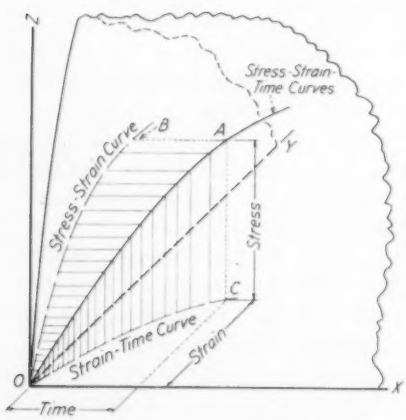

FIG. 1.—Construction of Stress-Strain-Time Diagram.

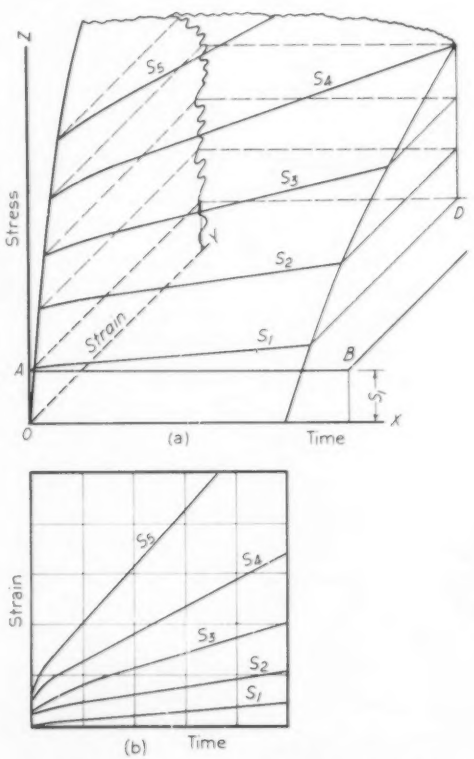

FIG. 2.—Determination of Strain-Time Diagrams from Stress Surface for the Condition of Constant Stress.

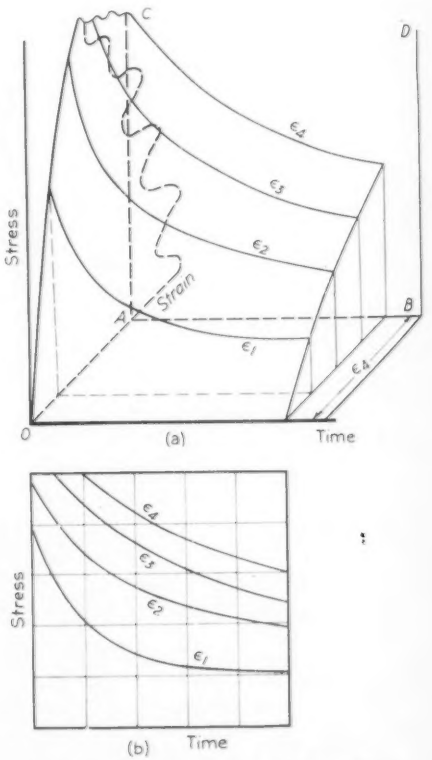

FIG.3.—Determination of Stress-Time Diagrams from Stress Surface for the Condition of Constant Strain.

The intersection of any horizontal plane such as *ABCD* in Fig. 2(*a*) with the surface gives a line indicating the strain-time relationship for the material when it is subjected to a constant stress. The magnitude of the constant stress is the distance of the horizontal plane above the reference plane (the *x-y* plane). This curve obtained as the line of intersection is the type usually obtained in creep tests, in which the material is subjected to a constant load (and stress) and strains are measured over a period of time, as shown in Fig. 2(*b*).

The intersection of any vertical plane parallel to the time axis (such as *ABCD* in Fig. 3) with the stress surface gives a line indicating the stress-time relationship for a material subjected to a constant strain. A material subjected to a constant strain may show a decrease in stress over a period of time due to plastic yielding.

The intersection of a vertical plane parallel to the strain axis (such as *ABCD* in Fig. 4) with the stress surface will give the stress-total strain relationships after the period of loading equal to the distance of the plane from the origin.

The intersection of a vertical plane through the stress axis (such as *OBCZ* in Fig. 5) with the stress surface will indicate the stress-strain-time diagram for a constant rate of application of the strain. The rate of strain is given by the slope which the plane makes with the time axis, that is, by the tangent of the angle *BOX*. This curve is representative of the condition usually obtained in the conventional tension or compression test using a gear type test machine which maintains approximately a constant rate of strain. A low rate of strain is given by a plane which makes a small angle with the time axis, while a high rate of strain is given by a plane making a large angle with the axis. The stress-strain diagram for the limiting condition of instantaneous loading is given by the intersection of the stress surface with the stress-strain plane. As the rate of strain becomes large approaching the limiting condition, the type of loading becomes what is usually known as impact loading.

The intersection of an inclined plane passing through the strain axis (such as *OYBC* in Fig. 6) with the stress surface will give the stress-strain-time relationship for a constant rate of application of stress. The rate of application of stress is given by the slope which the plane makes with the time axis. This condition of loading may be obtained with hydraulic testing machines having the appropriate rate-of-loading indicators and controls.

RESULTS

At the present time there are but few sets of stress-strain data available for the condition of very rapid loading, and most of those available are taken under conditions of decreasing rate of strain. Therefore little exact information can be given, but many interesting conjectures can be made concerning the shape of the stress surface near the stress-strain plane. Many questions yet remain to be answered regarding the behavior of materials under impact loadings at and above the transition velocity discussed by Mann[4] and also at and above the speed equal to the speed of sound through the material.

However, many data are available for lower rates of loading, both under the condition of constant rate of application of strain, and constant rate of application of stress, as well as under conditions in which neither rate was held constant. With the recent attention given to creep studies, there are

[4] H. C. Mann, "High-Velocity Tension-Impact Tests," *Proceedings*, Am. Soc. Testing Mats., Part II, Vol. 36, p. 85 (1936).

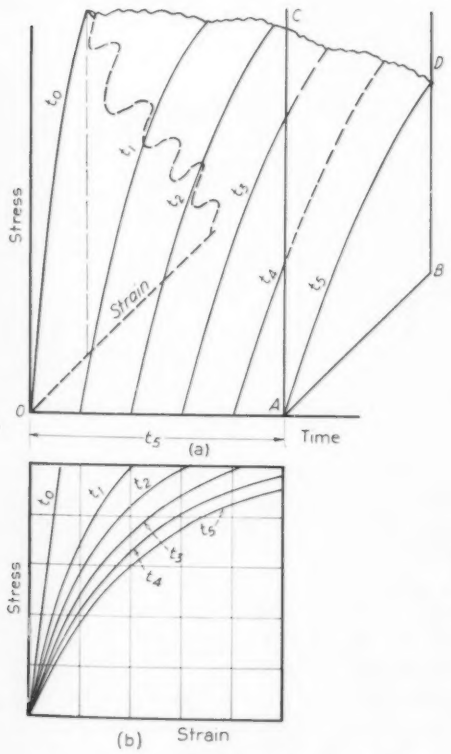

FIG. 4.—Determination of Stress-Total Strain Diagrams from Stress Surface for Different Time Intervals.

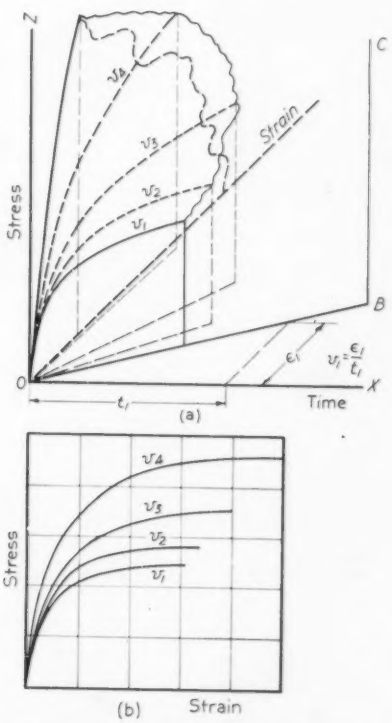

FIG. 5—Determination of Stress-Strain Diagrams from Stress Surface for Condition of Constant Rate of Application of Strain.

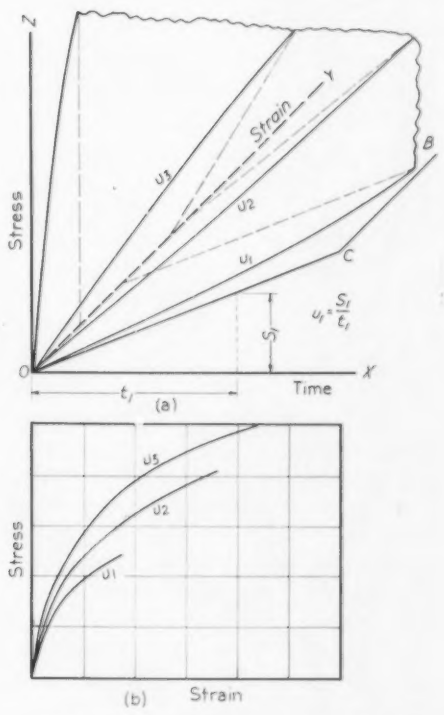

FIG. 6—Determination of Stress-Strain Diagrams from Stress Surface for Condition of Constant Rate of Application of Stress.

many data available for indicating the behavior of some materials under long-time loadings.

Almost without exception, the data indicate that the rate of loading has an effect upon the properties of material. An increase in the rate of loading tends to increase the elastic and ultimate strengths. For some materials the differences over a wide range of speeds is slight; for others, often the more plastic materials, an increase in the rate of loading has a marked effect in increasing the strength.

An increase in the elastic and ultimate strengths for higher rates of loading means that the stress surface will be higher near the stress-strain plane, that is, when the elapsed time of loading is small, and will slope downward with higher values of time. This result is in agreement with the observation that for stresses near the ultimate, the stress will decrease with time if the strain is maintained at a constant value. That is, the intersection of the surface with a vertical plane indicating constant strain will give a curve which slopes downward with increasing time as shown in Fig. 2. It is also in agreement with the observation, commonly noted in connection with creep tests, that an increase in the magnitude of the stress will result in a higher rate of creep, since creep-time curves represent contours on the stress surface.

If the creep-time diagrams are straight-lines (as in the so-called "second stage"), the stress surface will be a plane, tilted with respect to the axes. Where the diagrams curve, as in the last stages of creep before fracture, the stress surface must flatten out. The flattening is in agreement with the flattening of the conventional stress-strain diagram near the ultimate strength.

If the stress developed is dependent upon the rate of loading, a horizontal line in the surface (representing constant stress) will not be parallel to the time axis. If the stress is independent of the rate of loading, every horizontal line will be parallel to the time axis, and the stress surfaces will be relatively smooth, with every test curve drawn on the surface giving an identical projection on the stress-strain plane. Conversely, if the stress developed is dependent upon the rate of loading, then two lines on the surface representing different test conditions will have different projections. That is, the stress-strain diagram for the condition of constant rate of application of stress will be different from the stress-strain diagram for constant rate of application of strain.

It is possible to classify types of plastic action by the types of stress surfaces produced, but such classification is beyond the scope of this paper.

DISCUSSION

MR. ROLAND VOKAC[1].—I should like to ask Mr. Murphy if, in the generation of these stress-strain-time curves, he holds to the point of view that the same surface can be generated irrespective of whether one maintains a series of constant velocities of strain or a series of constant velocities of stress while testing. In other words, will the curved surface develop in the same way if you run say tests at five strain velocities on a given material as when you run tests at five stress velocities on the same material?

MR. GLENN MURPHY[2].—A conclusive answer to that question cannot be given until we have additional experimental evidence, and perhaps not even then. It might be true for one material and not true for another material.

MR. VOKAC.—My experience has been in the physical testing of asphalt and asphalt mixtures for paving purposes. The behavior of these materials during test indicates they are generally plastic and perform similarly to metals at elevated temperatures. In my own work I have found that it is immaterial whether we use a constant rate of stress or a constant rate of strain in order to develop the surface in terms of these two variables and time. I am interested to know whether your studies lead to the same conclusion.

MR. MURPHY.—I have not plotted any three-dimensional diagrams for asphalt. If the material is such that its stress-strain diagram is the same, regardless of whether a constant rate of stress or a constant rate of strain is used in its development, the stress-strain-time diagram will be a sort of cylindrical surface developed by moving the entire stress-strain diagram along the time axis. That is, every horizontal line in the surface will be parallel to the time axis.

MR. VOKAC.—That, then, brings us up to the other question I had in mind. Is not your illustration showing planes that represent constant time values of purely academic nature? Or does it picture some specific conditions of testing procedure with which I may not be familiar?

MR. MURPHY.—The curves on the planes of constant time represent the relationship between stress and the strain developed at the given time. They are not stress-strain diagrams. One of the curves could be used for determining the amount of strain which would be developed in the material after a given time for a stress held constant up to that time.

MR. C. H. GIBBONS[3].—As you know, we are manufacturers of testing equipment. A number of years ago the question came up as to whether or not it might be possible to draw or to prepare simultaneous stress-strain-time graphs, and at that time we went so far as to prepare the necessary sketches, so that I can assure you that it can be done. So far as I know, this feat has never been accomplished, but it can be done with relative ease by adaptation of commercially available equipment.

MR. B. B. BETTY[4].—The value of an analysis such as Mr. Murphy has given comes by virtue of its taking the "lightning" and mystery out of plasticity and its giving us a certain confidence and familiarity with creep characteristics which more readily will enable us to grasp and tackle problems arising in all kinds of fabrication and forming operations. There is very much of practical value to be derived from this study. Now that I am working on high-nickel alloys, I have projected an extensive investigation of the rate of creep of nickel alloys, particularly those that are best adapted to high-temperature service. I hope to obtain sufficient data to enable me to arrive at a feasible mathematical analysis which presumably will be of such a form as Mr. Murphy has just presented. I expect to submit a manuscript describing this work either to this Society or to The American Society of Mechanical Engineers, depending on the nature of the analysis which is necessitated.

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[1]Paving Engineer, Research Division, Technical Dept., Barber Asphalt Corp., Barber, N. J.

[2]Associate Professor of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa.

[3]Technical Adviser, Testing Machine Division, Baldwin-Southwark Corp., Philadelphia, Pa.

[4]Research Engineer, The International Nickel Co., Huntington, W. Va.

Welding Research, Particularly Industrial Research

By G. F. Jenks[1]

RECENT years have witnessed a remarkable technical cooperation both in this country and abroad. Engineers have found it profitable to contribute to the general store of technical knowledge and to draw from that store the experience of others. These contributions have included the results of experimentation, both of special investigations and of developments and practices built up over a long period. The experimentation and deductions made therefrom have disclosed the need for further information, thereby encouraging research.

The growth of industry has been accompanied by a demand for simplification and standardization. In such work conflicting interests cannot be satisfied except through an understanding of the fundamentals upon which such work is based. Long experience normally is a safe practice in the preparation of standards and specifications. However the demands for both efficiency and economy in industry have lead to the questioning of experience. Thus, incidental to the preparation of standards and specifications, there arises the need of more knowledge or of research.

The welding industry is comparatively young. Economies in production have resulted in its rapid growth. Although the process is simple in operation the phenomena attending its use are extremely complicated. The efficient and safe use of welding requires an understanding of these phenomena. Long experience, a safe guide in many of the older industries, is not available to the welding industry. Research is the logical method to obtain the needed information.

The major problems in welding are of a general nature. They are not peculiar wholly to the development of equipment nor to the production of base metals or filler materials. Some pertain to these developments but are of such general nature that the industry as a whole and not a single producer must assist in their solution. Others pertain to the process in which producers of materials, fabricators of welded structures, and the ultimate consumer of the structure are all involved. Under such conditions of general interest cooperative research is a natural development in the industry.

This briefly explains the reasons for the organization of the Welding Research Committee under the Engineering Foundation. This article concerns the Industrial Research Division of that Committee.

INDUSTRIAL RESEARCH DIVISION OF THE WELDING RESEARCH COMMITTEE

The Industrial Research Division was organized under the hypotheses that cooperative research can best be conducted by all interests involved working in and through a single group or committee and that such group or committee must have the power to initiate and conduct its technical activities within a specified scope, subject to general approval and financing by an overhead coordinating body. In organizing the Division and its various committees care has been taken to include producers, fabricators, consumers and general interests, and to obtain representation of all the various industries involved and those engineers who have become recognized as experts in the field of the Committee's activities.[2] The organization is of the holding company type in that the committees of the Division are the operating units, subject to coordinating and financial control by the Division and by the parent Welding Research Committee. In this respect it differs from most research committees. In a field as broad as that covered by the Division, however, great authority and responsibility must be given each committee if the highest type personnel of the industries are to be obtained for committee membership.

The Division has committees covering each of the important base materials: Carbon Steels (Dr. J. C. Hodge, chairman); Low-Alloy Steels (J. H. Critchett, chairman); High-Alloy Steels (Dr. S. L. Hoyt, chairman); Copper Alloys (Dr. D. K. Crampton, chairman; Aluminum Alloys (G. O. Hoglund, chairman; and Nickel Alloys (O. B. J. Fraser, chairman). It also has organized committees covering scopes of work independent of a particular base material: Methods of Test (Prof. M. F. Sayre, chairman); Weld Stresses (E. Chapman, chairman); Non-Destructive Tests (Dr. H. H. Lester, chairman); Resistance Welding (G. S. Mikhalapov, chairman); and Fatigue (Structural) (Jonathan Jones, chairman). Other committees will be set up as needed.

WELDABILITY

One of the persistent problems of the industry is that of weldability of steels. Committees of the American Society for Testing Materials have been concerned with the behavior of carbon and manganese in steels of weldable grades in order that their specifications may reflect safe practices in industry. Steels of all carbon and manganese contents are being welded under technique and conditions found suitable. But there are as yet neither recognized data of the properties of the welded joint for many compositions and under some conditions of welding and service use, nor commonly accepted tests to measure weldability.

There is little difficulty in producing filler metals that develop in the weld the full strength and ductility of the parent metal. In the welded joint the parent metal is affected by the welding process. The zone just beyond that fused in the welding process is raised to a temperature beyond its critical range and then cooled at a rate dependent upon various size, time, and temperature factors as well as upon properties of the material. Under some conditions, high resultant hardness may be produced in a narrow zone just beyond the fusion zone. Excessive hardness is objectionable and may be unsafe because of the crack sensitivity of the zone and because of the nonuniform plastic adjustments of a zone containing high-strength unductile metal adjacent to a low-strength highly ductile one.

CARBON-MANGANESE PROBLEM

The Carbon Steel Committee has drawn up a program to make a comprehensive study of a series of steels containing

[1] Chairman, Industrial Research Division of the Engineering Foundation Welding Research Committee.

[2] For organization of the Division and its various committees and their personnel see page 2 of Supplement of the December, 1938, issue of *The Welding Journal*, Vol. 17.

varying amounts of carbon and manganese in plates varying from light to heavy made by different processes.[3] The work contemplates the complete examination of the weld metal, of the heat-affected zone, and the joint as a whole.

Some financial support has been received for this project but the bulk of the financing remains to be done. When financed it is probable that some modification of the committee's program will need to be made to meet the changed conditions at that time.

Much is being accomplished in a study of weldability by various industrial and other laboratories. In no place, however, is a program being carried out which covers a planned thorough investigation of steels of the range of carbon and manganese used industrially. It is therefore difficult or impracticable to correlate the various researches conducted under various and partly unknown conditions and obtain a true picture of the problem. It will be cheaper to industry to obtain an authoritative definite answer of these problems rather than duplicate partial programs to obtain the answer to some specific problem. The program is an ideal one for cooperative effort.

ALLOY STEELS

The Low-Alloy Steel Committee has studied the various steels being marketed and grouped them by physical properties and by general experience as to weldability. Any complete study of the influence of various alloying elements on weldability requires basic information on the influence of carbon and manganese. When such authoritative information is available it will be practicable without great expense to study the influence of any element or group of elements. Of course considerable information is already available on the welding properties and characteristics of these steels. There are available, however, few data obtained under such controlled conditions that they can be accepted as final and authoritative. The fabricator and user of welded structures has a need for more complete knowledge.

Some subcommittees of A.S.T.M. Committee A-1 on Steel which are concerned with the preparation of specifications for low-alloy steel plates and castings of weldable quality have now a need for more definite information on the behavior of various elements in the welded joints and for acceptable tests to measure such behavior.

The High-Alloy Steel Committee is concerned especially with the necessity of heat treatment of welded structures and the effect of heat treatments upon corrosion and physical properties and the relieving of internal stresses. The problem is complicated because of the current use of various elements as stabilizers of such steels. Information of this character is desired for specification work by A.S.T.M. Committee A-10 on Corrosion-Resistant Alloys. The problem is one in which results may be expected from cooperative research performed in various laboratories under a general program set up by the committee, the results from each cooperating laboratory being made available to the committee.

The Aluminum Alloy and the Nickel Alloy Committees have been engaged on cooperative research programs, parts of which have been conducted in various laboratories under committee supervision. Some results have been published and others will be upon completion of current work.

TESTING AND RELATED WORK

The Methods of Testing Committee has been concerned primarily with the crystallization of thought in respect to the various tests used. Its most recent work was the organization of the round table discussion on weldability which was a part of the recent American Welding Society's annual program at Chicago.

The Weld Stress Committee is studying the possibility of conducting a research to determine the behavior of welded joints in fatigue under repeated longitudinal tension and synchronous internal radial pressure. This simulates the condition of bilateral stresses which often occur in the welded structure. Little, if any, precise knowledge is available as to the behavior of metals in fatigue under such loading. Because of the presence of residual stresses in some welded structures which under service conditions may result in bilateral stresses, the investigation is of prime importance to the welding industry. The preliminary work involves the construction of equipment, the design of a hollow specimen and the perfecting of the technique of applying and measuring the loading of the specimen and the resulting stresses. If found feasible to complete the preliminary work with available funds, it is hoped to inaugurate the program in the near future.

The Non-Destructive Test Committee has a minor program under way in a study of secondary radiation. Its major problem in cooperation with A.S.T.M. Committee E-7 on Radiographic Testing is the collection and interpretation of data by which more definite correlation may be made of defects shown in radiographic films with physical properties of welded joints and endurance life of the structure. It is also concerned with current developments of other methods of nondestructive testing, especially magnetic methods.

The Resistance Welding Committee in cooperation with the Fundamental Research Division is maintaining a research fellow at the Rensselaer Polytechnic Institute in the study of some fundamentals of resistance welding. So far, the principal investigations have been made on cold-rolled auto-body sheets, hot-rolled low-carbon steel pickled strips, and polished stainless steel strips. The operations of the committee immediately disclosed the necessity of preparation of standards of testing. Such standards are about ready for presentation. The major program involves an investigation of each variable of spot welding under controlled conditions and studies of the properties and structure of the weld and the welded joint.[4]

In the operations of this committee the elimination of as many variables as practicable and the strict control of other variables are essential for satisfactory data. Laboratory facilities not generally available to spot welding production plants are also needed. The work is best conducted in an independent laboratory in which trained personnel and adequate equipment are available and which enjoys the confidence of industry in the standards of its work. The preparation of programs, supervision of work, and formulation of conclusions by a research committee insures the work being corre-

[3] For the original provisions of the program see *The Welding Journal*, Vol. 17, Research Supplement, page 2 (Jan. 1938). The program has been modified in details to include processing methods as a variable and to provide preliminary work before execution of a complete program.

[4] The most recent papers published as a result of these investigations are two by W. F. Hess and R. A. Wyant. See *The Welding Journal*, Vol. 18, pp. 329S and 348S (Welding Research Supplement for October, 1939).

lated with industrial needs and its conclusions being applied in industrial practice.

The Fatigue (Structural) Committee is conducting an investigation of the fatigue strength of welded joints at the University of Illinois. Equipment available there has a capacity for repeated loadings in tension and compression up to 200,000 lb. This permits the use of welded joints of greater cross-section than possible elsewhere.[5] The work has advanced sufficiently that the committee may be expected in the near future to draw some important conclusions on butt joints. Work on butt joints will be continued, but during the coming year emphasis will be placed on joints made with fillet welds.

The work is conducted under a cooperatively financed program under committee supervision. It seems probable that the results are of such fundamental importance that industry will desire an acceleration of the programs, which is possible at reasonable expense by the addition of equipment.

There are other fields in which cooperative welding research work might be conducted to the profit of the industry. Such work, however, awaits a more generous financing of the Division's operations.

[5] For results of the University of Illinois work to date see paper on "Fatigue Strength of Welded Joints in Structural Plates" by W. M. Wilson and A. B. Wilder, read before the American Welding Society Oct. 23, 1939.

BENEFITS FROM INDUSTRIAL RESEARCH DIVISION

In conclusion it is believed that the Division's operations have justified its organization. Its round tables have stimulated investigations. Individual laboratories acting cooperatively under committee supervision have furnished the industry with the solution of many problems. Its cooperatively financed programs are providing fundamental data in fields in which welding progress is handicapped by lack of information. In other fields it offers an organization to undertake needed work when financed.

The organization furnishes fabricators and consumers an opportunity to outline their problems of processing and of service use. To producers it furnishes a reliable statement of conditions of use of materials. Producers now expend large sums to investigate problems of individual fabricators and consumers. Many of these problems might be solved more economically and effectively in supervised cooperative work. The publication of the details and results of research program accelerate progress of the art and the growth of the industry.

Discussion on Radiographic Sensitivity

MR. MYRON ZUCKER[1] (*by letter*).—In "Aspects of Radiographic Sensitivity in Testing with X-rays," published in ASTM BULLETIN of October, 1939, Mr. Lester gives valuable data on the relation of permissible relative sizes of focal spot and flaw, and relative values of film-flaw and flaw-tube (d/t) distances.

One precaution in such discussion might bear emphasis: in comparing size of flaw with size of X-ray focal spot, the projected area of the latter across the line between it and the flaw must be considered, rather than the area projected in the central axis of the X-ray beam. This is especially important when the target has the common construction (i.e., in a plane 71 deg. from the direction of the electron beam) because the equivalent size of spot may vary rapidly with position of flaw with respect to the axis of the beam.

This effect was brought out in our work of X-raying wood poles. After inspecting many radiographs, it was noticed that a remarkable number of poles appeared rotten on the right side, judging by the fuzziness of the growth-ring bands. Investigation showed that the change in projected area of a nominal 1-mm. target from left to right could easily account for the change from sharp to fuzzy delineation of marks about 1-mm. wide and 6 in. from the film, with 36-in. tube-film distance.

The effect was overcome by aiming the X-ray beam as far to the right as possible, minimizing equivalent target size for the elements on the right side of the film. Although wide film angles were required to produce the obvious results mentioned here, the same effect holds for metal radiography with small beam angles. It would seem to be worth remembering when studies as fine as those of Mr. Lester and Mr. Hicks are being conducted.

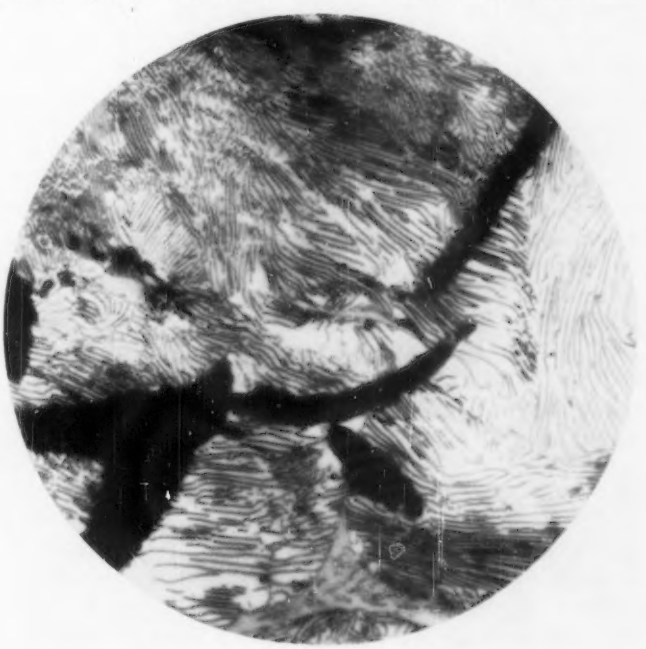
[1] The Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

Mr. H. H. Lester[2] (*author's closure, by letter*).—Mr. Zucker is quite right. The writer did not go into this effect, partly because it comes in to a greater extent with line focus than with elliptical or circular focus tubes, and line focus tubes were not available for study. The effect is well known and is recognized in the A.S.M.E. Code for Unfired Pressure Vessels by the stipulation that penetrameters be placed at the ends of the radiographic film. The effect should have been mentioned in the paper.

[2] Senior Physicist, Watertown Arsenal, Watertown, Mass.

"Fine Pearlite in Gray Cast Iron as Cast (X2500)"
(Reduced one-half in reproduction)

Awarded prize, Photomicrographic Section, A.S.T.M. Photographic Exhibit. By J. E. Wilson, Bausch & Lomb Optical Co., Rochester, N. Y.



ASTM BULLETIN

Published by

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No. 101 — December, 1939

District Meetings

TWO district meetings have recently been held, one in Chicago, the other in St. Louis, sponsored by A.S.T.M. District Committees in these industrial areas. The Chicago meeting featured a President's Night in honor of President H. H. Morgan who delivered an address on "Material Specifications and Their Practical Importance."

The St. Louis meeting, the first organized meeting of members in this district, had as its technical feature a talk by L. A. Watt, Head, Technical Service Dept., Monsanto Chemical Co., on "The Progress in Plastics."

A third district meeting is being held on December 12 under the auspices of the New York District Committee with papers and discussion on shipbuilding. Another meeting is being developed by the Philadelphia District Committee.

These meetings are arranged by the various District Committees as one of their contributions in promoting the interest of the Society in the respective areas. With no local sections, which are such strong sources of support to many professional societies, the technical set-up of the A.S.T.M. precluding such groups, the activities of the District Committees are extremely significant and merit the whole-hearted support of each member in the areas concerned. With two dinner or technical meetings at most during the year, members are not burdened with these events. The policy followed by the local groups is to have a real worthwhile meeting or two—rather than several get-togethers with perhaps less satisfactory program.

Each District Committee cordially welcomes to these meetings all who are concerned with the field of engineering materials. A.S.T.M. members may wish to take advantage of the meetings to invite their business associates and friends in other companies who should be interested.

No Let-Up

IT MIGHT be expected that with the passing of the "Book of Standards' year," a large number of the committees which have been extremely active getting standards in the best possible shape for inclusion in the Book of Standards and completing new specifications would find a period of rest in order.

Statements of committee activities furnished by most of the groups during the late summer and activities in certain materials fields evidenced at recent meetings, brief discussions of which are included in other portions of this BULLETIN, indicate that if there has been a rest period, it certainly was not a long one.

Certainly it seems a conservative prediction that there will be no diminution in the output of A.S.T.M. The work on standardization and research in the field of engineering materials goes ahead with momentum, if anything, on an upward trend.

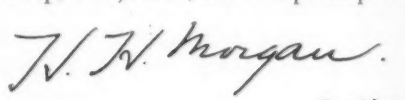
"LET OTHERS KNOW"

Our members know that they get many times the cost of membership from the *finished* work of our Society in the Book of Standards, Technical Papers, the BULLETIN and other publications. This finished work is the product of the technical knowledge and cooperation of those members who actively participate in committee activities. Such members net values many times more through their personal contact with leading authorities and technicians in the field of materials covered. This personal contact and acquaintance with men in similar work in other industrial operations throughout the country is invaluable.

Already many of our active members are using our publications and committee activities as a training school for their younger technical men, and have found it extremely valuable. More of our members should do this.

I earnestly ask that you tell other individuals and other companies what you get out of A.S.T.M. specifications and activities, and when you do, it will mean new members for the A.S.T.M. Every new member secured is going to mean that you will get that much more value out of the Society work.

Let others know what you get out of your membership. They will want membership, will join us, and will participate.



President

Action on Rivet Steel Specification Postponed

ON THE recommendation of Committee A-1 on Steel, the Executive Committee of the Society at its recent meeting approved postponement on an action which had been taken at the Annual Meeting and referred to Society letter ballot, involving the immediate addition to the Standard Specifications for Boiler Rivet Steel and Rivets (A 31 – 36) of requirements covering so-called higher tensile strength rivets.

While the specification requirements for the new rivets were complete as far as chemical composition and tensile test requirements were concerned, it was discovered after the annual meeting that the existing bend tests in the specifications would not be applicable to the higher strength rivets.

The proposed chemical and tensile limits are being published in the back of the Book of Standards, Part I, as well as in the *Proceedings*, with a note that additional requirements are being studied and will be added in the near future.

When adequate bend test values are established (these will be discussed at the January meetings of the Steel Committee) it is expected that the complete revisions will be referred to the Society for action.

List of Standards Published

THERE has recently been issued a 32-page pamphlet providing a complete list, with the latest serial designations, of all of the 884 A.S.T.M. standard and tentative specifications, tests, definitions, etc. While this List is printed annually, it is particularly significant at this time because of the large number of changes made in the Society's standards during the past year, and also the many new specifications and tests listed for the first time.

The format has been changed in the interest of utility, thus enabling those who use the List to locate quickly the particular group of materials on which they are seeking information.

Copies of this List will be sent without charge to members of the Society for their own use, and if any member wishes a few copies for distribution to his associates or in connection with promotion of the Society's interests, a request to A.S.T.M Headquarters will bring the material promptly.

Early in the year (probably about January 25) there will be distributed to each member a copy of the Index to Standards and Tentative Standards which provides detailed references to the publications where the standard and tentative specifications, tests, and definitions appear. This is a more extensive publication than the List. The latter, of course, does not provide page references, but is of very definite service in connection with ordering specifications and in other ways.

Offers of Meeting Papers by February 1

COMMITTEE E-6 on Papers and Publications is extending to each member of the Society the customary invitation to offer papers for presentation at the 1940 annual meeting in Atlantic City on subjects relating to the properties and testing of engineering materials.

In order that as many as possible of the technical papers and committee reports can be preprinted in advance of the meeting, it is desirable that the program be developed early. Committee E-6 has fixed February 1 as the limiting date for receipt of offers but members who may be considering the submission of a paper are urged to send their offers to A.S.T.M. Headquarters *as soon as possible*. Suitable blanks which should be used in sending the necessary information with respect to the offer of a paper can be obtained from the Society offices. Each offer must be accompanied by a summary of the proposed paper in such detail that its scope is clear and also to point out features that in the author's opinion make the paper a desirable one for presentation and discussion.

Invitations to submit papers are not limited to A.S.T.M. members, many outstanding technical contributions to our *Proceedings* having been made by men who were not affiliated with the Society.

Important Features for 1940 Annual Meeting Include Chemistry Symposiums

OF the technical features being developed for the 1940 Annual Meeting of the Society which is to be held in Atlantic City, June 24 to 28, two are of outstanding significance especially to chemists, chemical engineeers and spectroscopists and others concerned with the field of analysis. One is a Symposium on Analytical Chemistry being developed under the joint auspices of the Division of Physical and Inorganic Chemistry, American Chemical Society, and the A.S.T.M. Dr. G. Frederick Smith, Professor of Chemistry, University of Illinois, is chairman of the Symposium Committee which includes a number of outstanding authorities, including Dr. G. E. F. Lundell, A.S.T.M. Vice-President and Chairman of Committee E-3 on Chemical Analysis of Metals. It is planned tentatively that two complete sessions will be devoted to this symposium.

The second symposium, being arranged under the auspices of Committee E-2 on Spectrographic Analysis, is on spectrochemical analysis, in anticipation of which the three round-table discussions were held at the 1939 Annual Meeting.

In addition to these features, another very interesting symposium of significance to those concerned with metals is in course of preparation through a special committee, this symposium to cover the Significance of Mechanical Properties of Metals. J. M. Lessells, Prof. of Mechanical Engineering, Massachusetts Institute of Technology, is chairman of the Symposium Committee which includes Messrs. G. F. Jenks, N. L. Mochel, H. F. Moore, and R. E. Peterson. The American Society of Mechanical Engineers' Applied Mechanics Division of which Professor Lessells is chairman, and other groups, will cooperate jointly in this feature.

Other sessions, some of which may take the form of formal symposiums are being developed, including one on "problems in the classifications of natural waters intended for industrial uses," which would be sponsored by Committee D-19 on Water for Industrial Uses, of which Max Hecht is chairman.

A Symposium on Radiography, under the auspices of Committee E-7 on Radiographic Testing, is under way and of interest to rather special groups of technologists, but nevertheless extremely significant in connection with work of materials, is a possible session on color and its use in the testing field.

Watch these Pages for Information Regarding the Next A. S. T. M. Golf Tournament

Shipbuilding—Subject of New York Meeting on Dec. 12

ON DECEMBER 12 at the Hotel Pennsylvania in New York City there is to be held a meeting sponsored by the A.S.T.M. New York District Committee featuring two illustrated talks, one on "Specifications in Shipbuilding" by Paul Ffield, Materials Engineer, Bethlehem Steel Corp. Shipbuilding Div., Quincy, Mass., the other covering "Metals Used in Yachts and Other Small Vessels" by George Wyland, Chief Engineer, Sparkman and Stephens, Inc.

In his talk Mr. Ffield, who is a member of the Society and a former British aviator, will emphasize factors governing the application of materials in shipbuilding. The influence of the fabricating processes on the selection and specification of material will be discussed and illustrated by slides. Movies will demonstrate the energy locked up in a ship sliding down the ways while launching. Another movie will show the *U.S.S. Quincy* rounding Cape Horn in a storm.

Mr. Olin Stephens, of whose firm Mr. Wyland is Chief Engineer was one of the designers of the *"Ranger"* and has designed many of the sail boats which have won races in the last few years. Engineering and specifications will be authoritatively discussed and an interesting movie is promised.

Following the talks the meeting will be thrown open for discussion.

The meeting session proper, the room location for which will be posted on the hotel bulletin board, will get under way at 8 p.m.. A dinner in the Cafe at 6:30 p.m. where dinners are available at $1.25 to $1.50 per person will precede the meeting, with a period for cocktails and assembling beginning at 6 o'clock.

A cordial invitation is extended to all members and their guests who are interested in the subject of this meeting. It is requested that those planning to attend the dinner notify the *Secretary* of the New York District Committee, G. O. Hiers, National Lead Co., Research Labs., 105 York St., Brooklyn, N. Y., so that reservations can be made.

Myron Park Davis, Chief Chemist and Metallurgist, Otis Elevator Co., Yonkers, N. Y., *Chairman* of the New York District Committee is directing the meeting arrangements in cooperation with other members of the District Committee.

Committee D-13 on Textile Materials

A LARGER number of members were present at the regular Fall meeting of Committee D-13 on Textile Materials held in New York City, October 18 to 20, inclusive, than at any previous meeting. Members present totaled 110; guests and visitors, 26. In addition to a general session of the main committee, the Advisory Committee and 24 of the 28 subcommittees held well-attended meetings.

Very interesting technical paper sessions and dinners have been features of each of the recent D-13 meetings, but to give members a free afternoon and evening to attend the World's Fair, they were not held this time.

Recommendations Affecting Standards.—At the general session a number of recommendations were approved for submission to letter ballot of Committee D-13. These included three proposed new tentative standards as follows: Methods of Test and Tolerances for Glass Yarns; Methods of Tests and Tolerances for Glass Tapes; Methods of Test for Woven Asbestos Cloth.

Revisions are being offered in the following standard and tentative standards: General Methods of Testing and Tolerances for Cotton Yarns and Threads (D 180 – 37); Specifications and Methods of Test for Fineness of Wool Tops (D 472 – 37 T); Specifications and Methods of Tests for Asbestos Roving for Electrical Purposes (D 375 – 37); Specifications and Methods of Test for Asbestos Yarns (D 299 – 37); Specifications and Methods of Test for Asbestos Tape for Electrical Purposes (D 315 – 37); Methods of Testing and Tolerances for Hose Ducks and Belt Ducks (D 181 – 36); Methods of Testing Pile Floor Covering (D 418 – 39).

Three existing tentative standards are to be recommended for adoption at the A.S.T.M. Annual Meeting in Atlantic City in June, namely, Methods of Testing and Tolerances for Continuous Filament Rayon Yarns (D 258 – 39 T); Methods of Testing Wool Felt (D 461 – 38 T); and Definition of Terms Relating to Textile Materials (D 123 – 39 T).

Work in Progress.—The committee has a large number of projects being carried on in its various subcommittees. Included are the following:

SPECIFICATIONS FOR:

twist testers
dish toweling
blanketing
cotton corduroy
upholstery fabrics

METHODS OF TEST FOR:

glass cloth and braids
rayon tire cord
commercial weight of rayon yarn and staple in cases or packages
seam slippage
sampling and scouring of raw wool
shrinkage of felt
quantitative determination of wool
heat transmission of blanketing
acidity of glass tapes
low stretch cotton tire cord
heavy woven fabrics
denier from short lengths of rayon yarn
resiliency of textile fibers
diameter of felt wicks
color fastness, wearing, and shedding characteristics of wool carpets
yarn number of metallic and plied metallic asbestos yarns
degree of mercerization of fabrics
thickness of glass, cotton, and asbestos fabrics

A number of studies are being made. These include: consumer wear tests on rayon fabrics; generic names for rayon fabrics; definitions relating to cordage fibers; comparison of breaking strengths obtained by different types of testing machines on glass yarns and jute yarns; aging test for fabrics; rate of loading on strength of cotton yarns; tension in twist determination on cotton yarns; moisture regain of heavy

Schedule of Meetings

DATE	COMMITTEE	PLACE
December 4	D-18 on Soils for Engineering Purposes	Washington, D. C.
December 11	C-12 on Mortars for Unit Masonry	Washington, D. C.
December 11-13	B-5 on Copper and Copper Alloys, Cast and Wrought	New York City
December 12	C-15 on Manufactured Masonry Units	Washington, D. C.
Week of January 8	A-1 on Steel	Philadelphia, Pa.
March 13-15	D-13 on Textile Materials	Charlotte, N. C.
March 4-8	COMMITTEE WEEK	Detroit, Mich.
March 6	SPRING MEETING	Detroit, Mich.
June 24-28	1940 ANNUAL MEETING	Atlantic City, N. J.

woven cotton fabrics; effect of heat on breaking strength of asbestos tapes.

There is a widespread activity in applying statistical methods in determining the number of tests which should be made so that the result of the test shall have a desired accuracy. For this purpose data is being accumulated through interlaboratory testing on: cotton yarns and threads; wool tops, felt, yarns and carpets. A proposed recommended practice has been developed for guidance in this work. The indication of the accuracy of the results will add materially to the value of the methods of test.

The spring meeting will be held in Charlotte, N. C., March 13 to 15, 1940. Plans are being made for a meeting which will help increase the interest of the South in the work of the committee.

Committee on Soaps Meets in New York

A SERIES of interesting meetings were held by Committee D-12 on Soaps and Other Detergents in New York City on November 2 and 3, there being present about 45 members and other technologists concerned with this committee's field of work.

In its report at the 1939 Annual Meeting, the committee submitted a number of important recommendations, including the adoption of some ten existing tentative specifications and tests as standard. Seven new specifications and methods were approved for publication for the first time.

Further impetus was given to the active standardization program at the New York meeting. Since it seems rather impossible to write chemical specifications for the various new detergents on the market, sulfonated alcohols, etc., the Subcommittee on Specifications is trying to develop a performance test to be used in evaluating this material. The problem is very difficult but the committee is making good progress.

Tetrasodium pyrophosphate and sodium sesquisilicate were studied and proposed specifications were suggested for study and consideration at the committee's spring meeting.

Salt water soap was also discussed and proposed specifications suggested.

Palm oil soaps, both pure and blended, low titre soaps, etc., were discussed exhaustively. These soaps, in particular, are used extensively in textile work. There seemed to be great interest in the types of specifications desired, especially as to whether one specification should cover pure and blended palm oil soaps or whether two are needed. It seems that 80 per cent of the palm oil solid soap used in textile work is made from palm oil blended with other oils, while only 20 per cent of the palm oil chip soap used is blended.

Committee D-9 on Electrical Insulating Materials

A LARGE number of standardization and research projects being carried on by Committee D-9 on Electrical Insulating Materials were discussed in detail at the regular Fall meeting of the committee held in New York City, October 26 and 27. Twelve subcommittees and sections met in addition to the main committee. Some 80 members and visitors were present for the series of sessions.

Definite recommendations are to be presented in connection with two of the committee's standards, one including the addition of a mold for power factor and water absorption specimens in the Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 39); the other concerning a revision in the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 – 39 T).

Some of the projects being carried on in the subcommittees include the following: a round robin test for developing a testing procedure to determine the acid and alkali resistance of varnishes; conditioning of thermal plastic specimens; specifications for laminated tubes for radio use; a test for power factor of laminated sheets parallel to laminations; a round robin test on sludge accumulation in oil and a high-pressure oxidation test; a revision of the dielectric strength test of oil; a dye penetration test for wet process porcelain; and methods of testing steatite.

Also under way are electrical measurements on glass; preparation of thread gages for pin-type glass insulators; round robin tests on measurement of power factor at ultra-high frequencies; round robin tests on various micrometers; procedure for measuring room temperature, and consideration of a standard temperature for use in the method of measuring power factor and dielectric constant of mica.

Two technical papers which will probably be offered for presentation at the 1940 A.S.T.M. Annual Meeting are being prepared by committee members. One deals with the results of the round robin tests on measurement of power factor at high frequencies; the other is concerned with the work that has been done on electrical measurements on glass.

It was announced that the 1940 spring meeting of the committee would be held in Washington, D. C., during March.

Activity on Pictorial Rusting Standards

A SUBJECT of great interest and concern in connection with the protection of iron and steel involving such subjects as corrosion, painting, etc., is that of developing a set of pictorial rusting standards. Recently, in Committee D-1 on Paint, Varnish, Lacquer, and Related Products, the feasibility of developing a standard scale was discussed for use as a basis for more definite reports on the progress of deterioration of film and the rusting of paint exposure tests on steel.

A special Pictorial Rusting Standards Subcommittee has been appointed by Committee D-1 to function under the chairmanship of J. C. Moore, Superintendent, Paint Plant, Sinclair Refining Co. This group is cooperating with Subcommittee XXIX on Painting of Structural Iron and Steel headed by A. J. Eickhoff, Chemist, National Bureau of Standards, and certain sections of Subcommittee VII on Accelerated Tests for Protective Coatings.

At a recent meeting of the subcommittee at A.S.T.M. Headquarters, three of the members showed panels illustrating various types of degrees of rusting which were studied in comparison with the Swedish rusting standards, a set of color reproductions of painted panels, showing the progression of failure and rusting. J. W. Iliff, E. I. du Pont de Nemours & Co., Inc., showed a number of colored slides illustrating the types and degrees of rusting which the committee is endeavoring to include in a rusting scale which can be used as a standard reference by the A.S.T.M.

The slides, in Mr. Iliff's opinion, indicated that it would

be necessary to have two sets of rusting standards, one which would illustrate the type of rust normally found on sandblasted painted steel surfaces; and one which would illustrate the type of rust encountered on steel which had not been sandblasted before painting.

After an extended discussion it was decided that Subcommittee XXIX and Group 6 on Accelerated Tests on Paints Applied to Iron and Steel of Subcommittee VII would use numbers 2, 4, 6, and 8 of the Swedish rusting standards since most of the panels included in their tests would produce a rust similar to that secured on sandblasted surfaces. In the meantime, Messrs. Moore and Iliff are to take the same standards and have colored pictures made therefrom for study by the committee at a later meeting. Also, these two men are to select panels illustrating four different degrees of rusting found on steel surfaces which have not been sandblasted. A picture is to be taken of these four panels and printed in color for discussion in Committee D-1.

It was the opinion of those present that it would not be possible for Committee D-1 to select any set of rusting standards which would illustrate all types of rust. Therefore, the subcommittee agreed to work upon the premise that their set of rusting standards should cover the primary types of rust.

Papers Scheduled for Meeting of Committee C-15 on Manufactured Masonry Units

A GENERAL invitation to attend its meeting to be held in Washington at the National Bureau of Standards on December 12 has been extended by Committee C-15 on Manufactured Masonry Units to all who are interested in this general subject. An interesting technical program has been developed comprising five papers. These papers will be presented in the morning and afternoon to be followed by the business meeting of the committee.

An outline of the program is as follows:

9:30 a.m. Paper by P. M. Woodworth on the properties of concrete masonry units.
This report will cover recent extensive investigations completed at the University of Wisconsin. It will also summarize the results of extensive investigations carried out during the past several years on the fire resistance, thermal insulation and strength properties of masonry walls and the durability, moisture content and absorption of concrete masonry units.

11:00 a.m. Discussion relating to concrete masonry.

1:30 p.m. Paper by J. W. McBurney on the frost resistance of clay building brick.
Mr. McBurney will summarize the extensive investigation on the resistance of clay building brick to frost action which has been under way at the National Bureau of Standards since 1928.

2:15 p.m. Paper by J. H. Hansen on the durability of Hudson Valley building brick.
This paper will discuss data obtained recently by a cooperative investigation between the Brick Manufacturers Association of New York, Inc., and Alfred University and also a critical review of the paper by J. W. McBurney.

2:35 p.m. Paper by H. G. Schurecht on researches relating to the durability of clay building brick.

2:50 p.m. General discussion of paper on durability of clay brick.

3:30 p.m. Paper by Frederick Heath, Jr., on the problem of efflorescence.
This paper will summarize the existing research in formation relating to efflorescence on masonry, as this may be relevant to the work of the newly created joint committee on efflorescence.

3:50 p.m. Discussion on efflorescence.

4:05 p.m. Business meeting.

The meeting will be under the direction of D. E. Parsons, *chairman*, and J. W. Whittemore, *secretary*, of Committee C-15.

Student Members Total 400

A REVIEW of latest statistics concerning student membership indicates that the total number of students who are connected with the Society is exactly 400. This figure is about 50 ahead of last year.

While these student members are studying at some 38 technical and engineering schools, a very considerable percentage is located in 17 schools, as indicated in the following list showing those schools where there are four or more student memberships:

College of the City of New York	127
Ohio State University	86
University of Delaware	36
University of Colorado	18
Cornell University	13
Rensselaer Polytechnic Institute	13
University of Pennsylvania	12
University of Kansas	10
Pratt Institute	9
Detroit Institute of Technology	9
Grove City College	7
Massachusetts Institute of Technology	6
Worcester Polytechnic Institute	6
Iowa State College	5
Polytechnic Institute of Brooklyn	5
University of Idaho	5
University of Illinois	4

In several of the above schools use is made of certain A.S.T.M. publications, including the Book of Standards, membership in the Society enabling the student to procure the books at a considerable saving. This accounts for quite a number of student memberships at these schools.

Another factor which influences the number of memberships at various schools is the so-called Student Membership Prize Award Plan. Under this plan student membership is awarded to certain students for outstanding scholastic work in the fields of materials such as testing laboratory, mechanics, etc., these awards being sponsored by interested members of the Society. This plan is in effect at the following schools, the name of the donor being given:

Cornell University	F. M. Farmer
Detroit Institute of Technology	F. O. Clements
Grove City College	A. E. Pew, Jr.
Iowa State College	H. P. Bigler
Massachusetts Institute of Technology	Arthur W. Carpenter
Rensselaer Polytechnic Institute	Herbert Spencer
University of Idaho	A. E. Peterson
University of Illinois	S. H. Ingberg
University of Kansas	Walter Bohnstengel
University of Pennsylvania	C. L. Warwick
Worcester Polytechnic Institute	S. Collier

Some 46 students at these schools each year are awarded with student memberships in the Society.

Student members receive the Year Book, ASTM BULLETIN, and a copy of any one of the several special compilations of standards, including the compilation of Selected Standards for Students. They are furnished on request any or all of the preprinted papers and reports presented at the annual meeting and many of the Society's publications are available to them at special reduced prices. Each year a number of students take advantage of the latter procedure in connection with their thesis work.

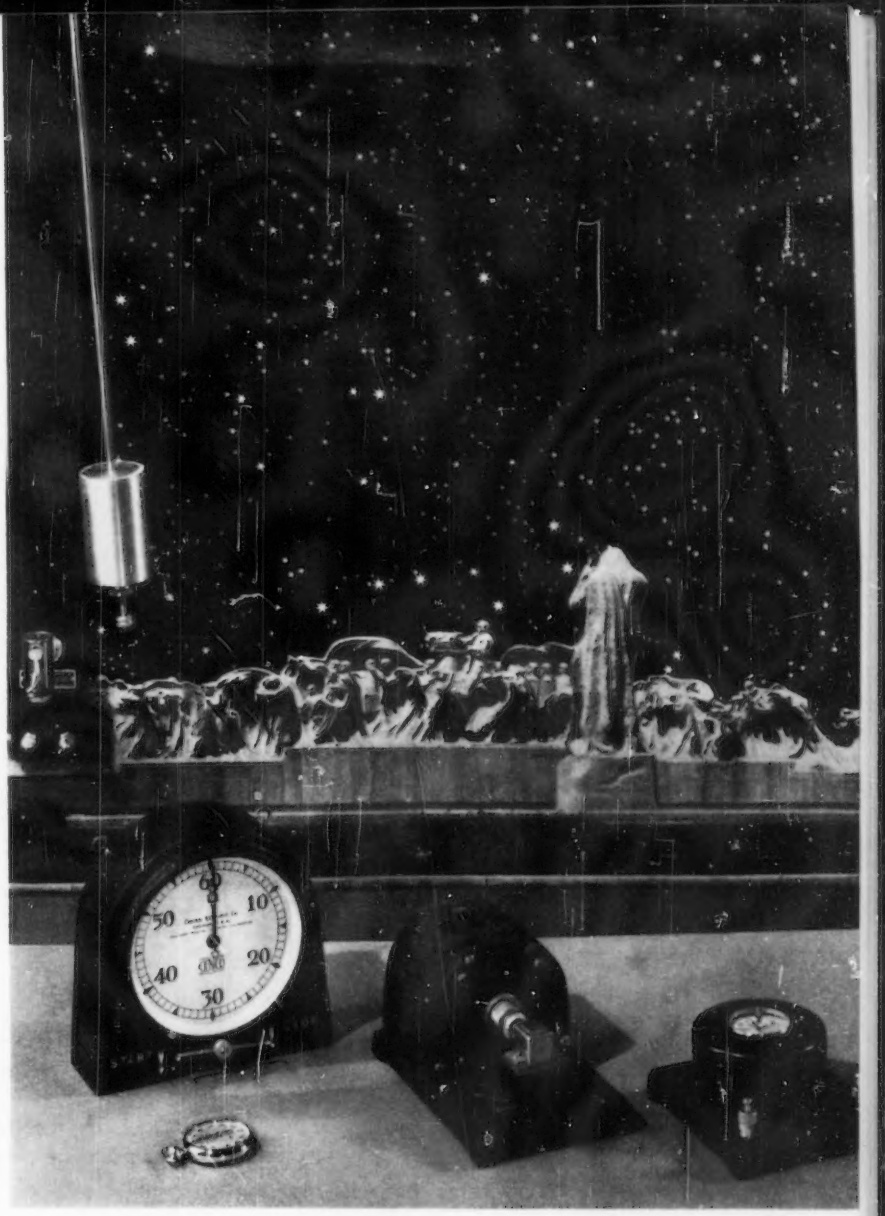
The list prices of the publications furnished students are considerably in excess of the annual dues, but it is in line with the Society's policy to make material available in engineering educational work at as nominal a figure as possible. The advantage to the Society of student membership is also

recognized. Students, particularly those who major in the field of materials, are prospective A.S.T.M. members and student membership acquaints them with the purpose and work of the Society, giving them some idea of the significance of A.S.T.M. activities.

A short article in the October BULLETIN announced the publication of the extensively revised Selected Standards for Students. This compilation of standards is used in some 40 engineering schools as a supplementary text in connection with testing laboratory and other courses involving materials. The book contains interesting historical information about the Society, its officers, and other data that should be of service.

Copies of this 203-page publication are sold at 50 cents each on orders of ten or more for educational work. The distribution of some 1400 to 1500 copies yearly is significant in connection with promoting knowledge of the importance of standardization and research in the field of materials.

Any member of the Society who wishes further information about student membership or the Student Membership Prize Award Plan can obtain this on request to A.S.T.M. Headquarters.



"Time—A Fundamental Measurement"

Awarded honorable mention, professional class, in the A.S.T.M. 1939 Photographic Competition. Submitted by Central Scientific Co., Chicago, Ill. (Photographer: Jahn & Ollier.) (In the background, Lorado Taft's "Fountain of Time.")

Committee D-3 on Gaseous Fuels

REPORTS presented at the meeting of Committee D-3 on Gaseous Fuels and its subgroups, held in New York during October, covering the activities of the different subcommittees showed quite satisfactory progress during the present year. Particular mention may be made of the accomplishments of the subgroups on determination of calorific value, specific gravity, impurities, and water vapor.

The subcommittee on determination of calorific value recently issued material covering requirements for mercurial thermometers for gas-flow calorimetry. In addition to the subcommittee members, these were supplied to manufacturers of thermometers for their review and comment toward the development of more satisfactory specifications. A study is now under way by a recently appointed subgroup on humidity control in heating value determinations. A number of trials made by different laboratories of applications of such a method have been found to give generally satisfactory results.

Necessary preliminary work in the testing of various types of specific gravity equipment at the National Bureau of Standards has now been largely completed and the specific gravity of the gas samples to be used determined. Completion of all tests on the equipment submitted will require considerable time. They should make available very complete data on existing instruments which would indicate those most desirable for various uses, and others to be employed under specified conditions.

Tests are now under way at different laboratories to make practical trial of the proposed method for determination of total sulfur by the Referees' apparatus. This was recently revised in view of comments received following its submission to subcommittee members.

Considerable work has been accomplished by the subcommittee on determination of water vapor content in the application of additional methods. Progress has been made on a colorimetric method involving the measurement of the color change with moisture of a solution of cobaltous chloride in butyl alcohol. The results so far appear promising although considerable additional study is still required. Investigation of a spectrographic method involving radiation changes in the infra-red under influence of water vapor has also been undertaken. This also appears to offer possibilities for precision work.

Dudley Medal Committee Appointed

THE Committee on Award of the Charles B. Dudley Medal has been appointed by the Executive Committee and consists of the following members:

F. E. THUM, *Chairman*, Editor, *Metal Progress*, American Society for Metals
R. R. LITEHISER, Chief Engineer, Bureau of Tests, Ohio State Highway Testing Laboratory, Ohio State University
F. P. PARTRIDGE, Director of Research, Hall Laboratories, Inc.

This committee will review the eligible technical papers presented at the 1939 annual meeting in Atlantic City and select the one of outstanding merit which constitutes an original contribution on research in engineering materials. The award will be made at the Forty-Third Annual Meeting in Atlantic City, June 24-28, 1940. This Medal was established in 1925 by voluntary subscriptions from members of the Society as a means of stimulating research, recognizing meritorious contributions to the *Proceedings*, and in commemoration of the first President of the Society whose leadership has profoundly influenced A.S.T.M. development.

New Book on Materials by Prof. A. H. White

AN INTERESTING new volume entitled "Engineering Materials" by Prof. A. H. White, Chairman, Department of Chemical and Metallurgical Engineering, University of Michigan, and a long-time A.S.T.M. member, has recently been published. It is pointed out that while the book is intended primarily as a text for engineering students, practicing engineers may be interested in the systematic presentation of recent advances in the field of materials.

Following a chapter entitled "Theoretical Introduction" which provides a working basis for the ensuing material, there is detailed discussion (11 chapters) of the field of ferrous and non-ferrous materials covering such subjects as effective heat treatment, influence of chemical composition and mill-finishing operations on properties, casting processes, steels with one or two or more alloy elements, etc. Some 70 pages of this section cover the major non-ferrous metals and their alloys.

There is an interesting section on corrosion and protection followed by chapters on rocks and their decomposition products, clay products, glass, slags, and refractories, with treatment of the following subjects in subsequent chapters: lime, gypsum, cements, fuels and combustion, water and its industrial utilization, soaps, organic preservative materials and protective coatings, plastics and related products.

Throughout the book, Professor White gives at the close of each chapter up-to-date references. What makes the book of considerable interest from the A.S.T.M. standpoint is the very widespread use he has made of information and data given in A.S.T.M. specifications and tests and in the various Society technical publications. Thus, he has incorporated in a very readable way up-to-date data on the properties of materials, information which is the basis of specifications covering the production and use of a wide range of engineering materials.

Copies of the 547-page publication can be obtained at $4.50 each from the McGraw-Hill Book Co., 330 West 42nd St., New York City.

Jerome Strauss Elected to A.S.A. Board

ON nomination by the Society, Jerome Strauss, Vice-President, Vanadium Corp. of America, has been elected a member of the Board of Directors of the American Standards Association, succeeding Dr. G. W. Thompson who recently resigned.

Mr. Strauss has been a personal member of the Society since 1916 and is also the representative of the Sustaining Membership held by the Vanadium Corporation of America. He is a graduate of City College of New York and received his M.E. degree, with honors, from Stevens Institute of Technology in 1913. He was chemist and metallurgist, Western Drop Forge Co. for three years, and from 1919 to 1928 was chief chemist and later materials engineer of the U. S. Naval Gun Factory in Washington. For two years beginning in 1917 he was an officer in the Ordnance Dept., U. S. Army. Since 1928 he has been chief research engineer of the Vanadium Corp., Vice-President since 1935.

He is very active in many phases of A.S.T.M. work, has been Chairman of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys since its organization in 1929. He participates in the work of several other committees – including B-3 on Corrosion of Non-Ferrous Metals and alloys, A-9 on Ferro-Alloys and A-1 on Steel. He is the A.S.T.M. representative on the Iron Alloys Research Committee of the Engineering Foundation. Mr. Strauss is affiliated with a number of other technical and engineering societies.

Mr. Strauss has recently transferred his headquarters from Bridgeville, Pa., to 420 Lexington Ave., New York City.

Industrial Management Medal Award to President of Johns-Manville Corp.

THE first award of the Vermilye Medal, to be awarded biennially by the Franklin Institute, was made on November 14 to Lewis H. Brown, President, Johns-Manville Corp. This medal named after its donor, a prominent executive in the textile industry and now Vice-President of the National City Bank, has for its purpose the stimulation, encouragement, and recognition of outstanding contributions in the field of industrial management. It is in this field that Mr. Brown has done notable work in recent years.

British Symposium Postponed

WORD has been received that the discussion on properties and testing of heat insulating materials which was to be held in London in November under the auspices of the British Joint Committee on Materials and Their Testing has been indefinitely postponed. Certain American technologists prominent in particular phases of this field were to have presented papers giving American viewpoints.

XXI. Long-Time Society Committee Members

Twenty-first in the Series of Notes on Long-Time Members

As a continuation of the series of articles in the ASTM BULLETIN comprising notes on the outstanding activities of long-time A.S.T.M. members, there are presented below outlines of the work of three additional members. In general, the men whose activities are described in this series have been affiliated with the Society for 25 years or more and have taken part in committee work for long periods of time. No definite sequence is being followed in these articles.

J. H. NEAD, Chief Metallurgist, Inland Steel Co., East Chicago, Ind., following his graduation from the University of Michigan and after a short period as instructor became associated in a metallurgical capacity with the H. H. Franklin Co., Syracuse, N. Y., the Watertown Arsenal, the Racine Steel Castings Co., and the Minneapolis Steel and Machinery

J. H. Nead H. B. Oatley W. B. Price

Co. He was a Captain in the Ordnance Department, U. S. A., during the World War, serving both overseas and in Washington.

From 1919 to 1931 he was Research Metallurgist and then Chief Metallurgist in the American Rolling Mill Co. and has been at Inland in his present position since that time.

A member of the Society since 1911, Mr. Nead has been active in various phases of committee and other work. For many years he was Chairman of Subcommittee I on Heat Treatment of Rolled and Forged Carbon Steel of Committee A-4 on Heat Treatment of Iron and Steel (now discontinued). At present he is a member of Committee A-1 on Steel, serving on Subcommittee XIII on Methods of Physical Tests and Subcommittee XIX on Sheet Steel and Steel Sheets; he also represents the committee on the Section on Bend Tests for Ductility of Committee E-1 on Methods of Testing. Mr. Nead has contributed numerous technical papers and discussions several of which are published in the A.S.T.M. *Proceedings*.

He is active in the work of other societies and is Chairman for 1939 of the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers. Last year he received jointly with his colleague, T. S. Washburn, the Robert W. Hunt Award of the Institute for an outstanding paper dealing with iron and steel.

W. B. PRICE, Chief Chemist and Metallurgist, Scovill Manufacturing Co., Waterbury, Conn., is a native of New Haven and it is not surprising to find, therefore, that he was graduated from the Sheffield Scientific School of Yale University in 1902, receiving honors in chemistry. Since that time he has been employed by his present company and has been chief chemist and metallurgist for over 30 years.

A pioneer metallurgist in the brass industry, he has done a great deal to place the industry on a sound scientific and technical basis. In 1911 he wrote the well-known book covering "Technical Analysis of Brass."

A member of the Society since 1913, Mr. Price has taken a very active part in numerous phases of the Society's technical work, particularly in the non-ferrous fields. He has been a member for many years of Committees B-2 on Non-Ferrous Metals and Alloys, B-3 on Corrosion of Non-Ferrous Metals and Alloys, B-5 on Copper and Copper Alloys, Cast and Wrought, D-2 on Petroleum Products and Lubricants, and E-4 on Metallography.

Mr. Price has been a leading figure in the field of standardizing methods of chemical analyses of copper and zinc. The methods for the battery assay of copper and the analysis of spelter which he was primarily responsible in developing were approved first by the American Chemical Society and later by A.S.T.M. in 1919.

He has prepared a large number of technical papers and reports which have appeared in scientific, technical and business journals, many having appeared in A.S.T.M. publications. He holds patents on a number of alloys in the field of his interest.

Among the societies with which Mr. Price is affiliated are the following: American Institute of Mining and Metallurgical Engineers, Society of Automotive Engineers, American Chemical Society, American Electrochemical Society, and Institute of Metals (British).

HENRY B. OATLEY, Vice-President, The Superheater Co., New York City, affiliated with the Society since 1913, was born in Rochester, N. Y. Following his graduation from the University of Vermont in 1900 with a degree of B.S., he was Draftsman, Division Engineer, and Testing Engineer of the American Locomotive Co. until 1910. Since that time he has been Mechanical Engineer, Chief Engineer, and Vice-President of The Superheater Co. A number of inventions relating to superheaters and other devices in locomotive and boiler use have been developed by Mr. Oatley.

He is one of a very important and essential group of A.S.T.M. members whose committee affiliations in the Society have not been significant from the standpoint of number of committees, but who have contributed immeasurably to the advancement of the Society's purposes by consistent and concentrated work on a few technical committees. Mr. Oatley has been one of the very valuable members of Committee A-1 on Steel for many years taking an active part especially in the work of Subcommittee IX on Steel Tubing and Pipe and Subcommittee XI on Boiler Steel. He has been a member of these committees for over twenty years. His intimate knowledge in these fields has been of great assistance to the committee in connection with many of its problems.

He is a member of a number of societies including the American Society for Metals, The American Society of Mechanical Engineers (he represents this society on Sectional Committee B 36 on Standardization of Dimensions and Materials of Wrought-Iron and Wrought-Steel Pipe and Tubing), the Society of Naval Architects and Marine Engineers, and the Engineering Institute of Canada.

PROPOSED METHODS OF TESTING EMULSION FOR USE IN DENSELY GRADED COLD ASPHALTIC MIXES

In developing a satisfactory specification for emulsified asphalt for use in densely graded cold asphaltic mixtures, Committee D-4 on Road and Paving Materials has found it necessary to consider several new methods of test, and active cooperative work is now going forward. It seems desirable to publish these proposed methods of test as information and for comments, which latter should be addressed to the Society, 260 S. Broad St., Philadelphia, Pa.

Modified Miscibility Test[1]

1. *Apparatus.*—The apparatus shall consist of the following:

(*a*) *Graduate.*—A 50-ml. graduated cylinder.

(*b*) *Beaker.*—A 400-ml. Griffin low-form beaker of heat-resistant glass.[2]

(*c*) *Glass Tubes.*—Three glass tubes, 7 mm. in outside diameter, 5 mm. in inside diameter, and 15 cm. in length, fitted with suitably bored No. 8 corks, adjusted as described in Section 2.

(*d*) *Supporting Strip.*—A strip of wood or metal, approximately 15 cm. in length, 2.5 cm. in width, and 0.5 cm. in thickness, with a hole 10 mm. in diameter in the center.

(*e*) *Crucibles.*—Three 15 or 25-ml. porcelain crucibles, or three 30-ml. beakers of heat-resistant glass.[2]

(*f*) *Oven.*—Constant temperature oven set at 163 C.

(*g*) *Balance.*—Analytical balance accurate to 0.1 mg.

2. *Apparatus Assembly.*—The position of the corks on the glass tubes shall be adjusted by placing 200 ml. of water at 20 to 25 C. in the 400-ml. beaker, placing the strip across the top of the beaker, and inserting a tube through the hole. The position of the cork shall be so adjusted that when the tube is supported by the cork resting on the strip, the lower end is immersed in the water to a depth of 1 cm. below the surface. In the same manner, the second and third tubes shall be so adjusted that the depth of immersion is 2.5 and 4.6 cm., respectively.

NOTE.—Due to slight differences in height and diameter of 400-ml. beakers as obtained commercially, it may be necessary to readjust the tubes when used in different beakers. It is highly advisable to have the third or bottom tube project into the emulsion so that the tip is within 1 to 1.5 mm. of the bottom of the beaker.

3. (*a*) *Procedure.*—With the sample at 20 to 25 C., 50 ml. of the emulsion shall be measured in the graduate and placed in the 400-ml. beaker. The graduate shall be washed with three 50-ml. portions of distilled water at 20 to 25 C. and the washings added to the beaker, the final volume being 200 ml. The emulsion and water shall be stirred until uniformly mixed, the beaker covered with a watch glass, and the mixture allowed to stand without disturbance for 2 hr.

(*b*) The three crucibles or beakers shall be weighed to the nearest 0.1 mg. After the diluted emulsion has been standing for 2 hr., a sample of approximately 1 g. shall be removed from the top layer and transferred to the crucible or beaker by using the 1-cm. tube as a pipette. The top of the tube shall be closed with the finger when inserting it to the proper depth. After removal, the adhering liquid on the outside of the tube shall be wiped off with filter paper, before transferring the sample to the crucible or beaker. In the same manner samples from the middle and bottom of the diluted emulsion shall be taken with the second and third tubes, respectively. The crucibles or beakers and emulsion shall be weighed and the weight of each of the three samples determined by difference.

(*c*) The samples in the crucibles or beakers shall be placed in the oven at 163 C. for 2 hr., cooled, and weighed. The amount of asphalt residue in the top, middle, and bottom levels shall be calculated. A difference of more than 4.1 between the residues in the top, middle, or bottom levels constitutes "appreciable coagulation" and shall be a cause for rejection.

Cement Mixing Test

A 50-g. portion of high-early-strength cement having a minimum surface area of 1900 sq. cm. per g. and conforming to the Standard Specifications for High-Early-Strength Portland Cement (A.S.T.M. Designation: C 74) of the American Society for Testing Materials[3] shall be used for this test. The cement shall be sieved through a No. 80 (177-micron) sieve and placed in a tin having a capacity of approximately 500 ml. The emulsion to be tested shall be diluted with distilled water to a residue of 55 per cent as determined by either distillation, or evaporation for 3 hr. at 163 C. A 100-ml. sample of the diluted emulsion shall be poured on the cement and the mixture stirred with a $\frac{1}{2}$-in. steel rod 60 times during 1 min. To this mixture 150 ml. of distilled water shall be added and the stirring continued for 3 min. The ingredients and apparatus shall be maintained at a temperature of approximately 77 F. (25 C.) during the mixing. The mixture shall be poured through a tared, 14-mesh, iron-wire sieve, and rinsed until the wash water is clear. The sieve shall be placed in a tared shallow pan, heated until dry, and weighed. The weight in grams of the material retained on the sieve and in the pan represents the percentage of the emulsion broken.

Dehydration Test

A 100-g. sample of the emulsion to be tested shall be placed in a tared, heat-resistant glass dish,[2] 77 mm. in inside diameter, 40 mm. in height, and having a flat bottom and straight sides. The dish and sample shall be placed in the center of a shallow pan about 5 in. in diameter, and 50 g. of granular anhydrous $CaCl_2$ shall be spread in the pan so that it surrounds the dish containing the emulsion. The entire unit shall then be placed in an oven at a constant temperature of 100 F. (37.8 C.). At the end of exactly 96 hr., during which time the sample shall not be disturbed by stirring or excessive movement, the loss in weight of the emulsion shall be determined. The dehydration loss shall be expressed as the ratio of loss in this test in 96 hr. to loss in the test for residue at 163 C.

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[1] This method is identical in substance with a modified miscibility test described in a paper by C. A. Downing, "Emulsified Asphalts—Some Characteristics and Properties," Assn. Asphalt Paving Technologists, presented at Chicago Meeting, February 1, 1939. This method represents a modification of a method presented by the same author in a paper on "A Study Concerning a Modification of the Present Miscibility Tests and Its Relation with Probable Settlements," *Proceedings*, Am. Soc. Testing Mats., Vol. 35, Part II, p. 546 (1935), which was published as an elaboration of the miscibility test described in the Standard Methods of Testing Emulsified Asphalts (A.S.T.M. Designation: D 244) of the American Society for Testing Materials, see 1939 Book of A.S.T.M. Standards, Part II.

[2] Pyrex glass is very satisfactory for this purpose.

[3] 1939 Book of A.S.T.M. Standards, Part II, p. 3.

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The Effect of Solar Radiation on the Heat Transmission Through Walls. F. C. Houghten, Carl Guberlet, and Albert A. Rosenberg. No. 96, January, 1939, p. 39.

Thermal Endurance.
Tests on the Thermal Endurance of Glass. S. R. Scholes. No. 97, March, 1939, p. 25.

Transverse-Loading Test.
Measuring Deflection in the Transverse-Loading Test of Cast Iron. A. I. Krynitsky and C. M. Saeger, Jr. No. 97, March, 1939, p. 23.

Water.
Report of the Joint Research Committee on Boiler Feedwater Studies. No. 99, August, 1939, p. 52.

Weighing.
Load-Weighing and Load-Indicating Systems. C. H. Gibbons. No. 100, October, 1939, p. 7.

Welding.
(See also **Radiography.**)
Discussion on Fatigue of Metals. R. K. Bernhard. No. 96, January, 1939, p. 20.
Welding Research, Particularly Industrial Research. G. F. Jenks. No. 101, December, 1939, p. 23.

Wire.
Fatigue Tests of Wire. C. P. Wampler and N. J. Alleman. No. 101, December, 1939, p. 13.

X-ray.
Aspects of Radiographic Sensitivity in Testing with X-rays. H. H. Lester. No. 100, October, 1939, p. 33.
Industrial X-ray Protection. Lauriston S. Taylor. No. 99, August, 1939, p. 23.
Non-Destructive Testing in the U. S.—Part II, Radiographic Methods. H. H. Lester, R. L. Sanford and N. L. Mochel. No. 96, January, 1939, p. 13.

Publications Issued on Electrical Insulating Materials, Cement, Rubber Products, Piping Materials, and Electrodeposited Coatings

SINCE the October BULLETIN when several special technical publications were announced, a number of other books and pamphlets have been printed and distribution made, including the special compilations of standards on Electrical Insulating Materials, and on Cement, specifications for Electrodeposited Coatings, specifications for Piping and Piping Materials for High-Temperature and High-Pressure Services, and the compilation of Standards on Rubber Products.

The compilation of standards sponsored by Committee D-9 on Electrical Insulating Materials is now well established, having been first issued in 1930. The 1939 compilation gives all of the 42 A.S.T.M. specifications and test methods in this field, covering insulating varnishes, paints, lacquers, and their products, molded insulating materials, plates, tubes, and rods, mineral oils for electrical insulation, ceramic products (glass, porcelain), solid filling and treating compounds, electrical tests, insulating paper, mica products, rubber products, and textile materials. In addition to these, it includes the latest Report of Committee D-9 with appended material covering requirements for cells used for measuring low power factor liquids and proposed specifications for rubber insulating blankets for use around electrical apparatus or circuits not exceeding 3000 volts to ground. Also included are committee-sponsored statements covering the significance of the following tests: dielectric strength, resistivity, impact, tensile strength (molded materials), tensile strength (sheet and plate materials), and power factor.

Copies of this publication can be obtained by members at $1.50, the list price being $2.00.

The volume of Standards on Cement gives in their latest approved form ten specifications and test methods. Four types of cement are covered, namely, portland, high-early-strength portland, natural, and masonry cement. Standard and tentative methods of tests cover chemical analysis, sampling and physical testing, compressive strength and fineness of portland cement. Specifications for sieves are included.

As in previous years, the extensive Manual of Cement Testing and Selected References on Portland Cement are also included. Comprising 100 pages in heavy paper cover this compilation can be obtained by members at 75 cents each, the price to non-members being $1.00.

Jointly with the American Electro-Platers' Society, the A.S.T.M. has published a 16-page pamphlet providing in compact form the three specifications covering electrodeposited coatings of zinc, cadmium, nickel and chromium on steel. This also includes the methods of test for local thickness of electrodeposited coatings on steel. Copies of this pamphlet can be obtained at 25 cents per copy.

The 1939 volume of A.S.T.M. Specifications for Pipe and Piping Materials for High-Temperature and High-Pressure Services is the second edition of this book. The first edition was promptly exhausted which is indicative of the reception accorded this book. Eleven of the specifications cover various types of pipe and tubing; four apply to castings, and three each to forgings and bolting. In addition, the classification of austenite grain size in steels is included for the first time. Four of the specifications approved as tentative this year are also given.

Copies of this publication, 135 pages, in special spiral ring binding with board covers, can be obtained by members at $1.00 each; $1.25 to non-members.

The compilation of standards sponsored by Committee D-11 on Rubber Products will give all of the 30 A.S.T.M. standards and tentative standards in this field. Since this book has not been issued since 1937, the current edition should be of distinct service to all those concerned with the production, purchase, and use of the wide range of materials covered. In addition to the standards there is included for convenient reference a list of recent sources of information on the testing of rubber, this bibliography covering some 8 pages.

Copies of this publication in heavy paper cover can be obtained at $1.25 to members, $1.75 to non-members.

Calendar of Society Meetings

(Arranged in Chronological Order)

HIGHWAY RESEARCH BOARD—19th Annual Meeting, National Academy of Sciences, December 4-8, Washington, D. C.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—Winter Meeting, December 27-January 2, Columbus, Ohio.

SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting and Engineering Display, Book-Cadillac Hotel, January 15-19, Detroit, Mich.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS—35th Annual Meeting, Blackstone Hotel, January 17-19, Chicago, Ill.

AMERICAN SOCIETY OF CIVIL ENGINEERS—Annual Meeting, January 17-20, New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Annual Winter Convention, January 22-26, New York City.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—Sixth International Exposition, Lakeside Hall, January 22-26, Cleveland, Ohio.

AMERICAN ROAD BUILDERS' ASSOCIATION—37th Annual Convention and Road Show, January 29-February 2, Chicago, Ill.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS—Annual Meeting, February 12-15, New York City.

AMERICAN CONCRETE INSTITUTE—36th Annual Convention, Palmer House, February 27-29, Chicago, Ill.

American Society for Testing Materials—Committee Week and Spring Meeting, March 4-8, Detroit, Mich.

Catalogs and Literature Received

C. J. TAGLIABUE MANUFACTURING CO., Park and Nostrand Aves., Brooklyn, N. Y. Catalog 1125C, 24 pages, describes the complete line of TAG Industrial Thermometers, giving information about their construction, utility, etc. Also described is a representative line of TAG Miscellaneous Thermometers, including metal and wood back, cup case, open V, iron wall, metal case, and others.

THE GAERTNER SCIENTIFIC CORP., 1201 Wrightwood Ave., Chicago, Ill. Bulletin 147, 7 pages, describes the Gaertner Toolmaker Microscope, the outstanding features of which are indicated as ruggedness of construction, simplicity of operation and accuracy in measurement.

PRECISION SCIENTIFIC CO., 1750 N. Springfield Ave., Chicago, Ill. Bulletin 305, 7 pages, entitled "What to Think About When You Buy Constant Temperature Laboratory Equipment." Included are a brief review of heat transfer principles and an outline of technical considerations affecting rate of heat transfer, variations in quantity of heat required, attributes of peak performance, and various aspects of efficiency.

AMERICAN INSTRUMENT CO., 8010-8020 Georgia Ave., Silver Spring, Md. Catalog 15, previously announced, describes in detail a large number of instruments and apparatus built in accordance with A.S.T.M. specifications, tests, etc., particularly in the fields of cement, concrete, mortar, aggregates, lime, gypsum, to which fields one section of the catalog is devoted; also soils, and petroleum and its products. The compliance of apparatus with A.S.T.M., Federal specifications, and A.A.S.H.O., is clearly indicated. The A.S.T.M. index should be of particular service in locating quickly items pertinent to a particular standard, these being listed in order of serial designations in the index to each of the three sections of the catalog. 33 pages devoted to cement, concrete, etc., 41 to soils and 71 to petroleum and its products.

Also, a four-page folder, Bulletin 2060, describing the Aminco-Yerzley Oscillograph for evaluating the properties of rubber and rubberlike materials used as vibration absorbers.

DR. F. LOEWENBERG, Mechanical Engineer, 10 East 40th St., New York City. Two-page description of Photoelectric Colorimeter in four standard models.

NEW MEMBERS TO NOVEMBER 21, 1939

The following 19 members were elected from October 4 to November 21, making the total membership 4231:

Company Members (3)

CLAY SEWER PIPE ASSN., INC., Benjamin Eisner, Chief Engineer, 945 Oliver Building, Pittsburgh, Pa.

TRUSCON STEEL CO., Russell Montgomery, Standards and Research Engineer, Youngstown, Ohio.

WHEATON CO., T. C., R. O. Smith, Chemist, Millville, N. J.

Individual and Other Members (14)

ALBRIGHT, A. R., Chief Chemist, Hecker Products Corp., Morris and Harding Sts., Indianapolis, Ind.

BASSETT, H. Y., Supervisor of Quality, Wolverine Tube Co., 1411 Central Ave., Detroit, Mich.

CAMP, C. S., Assistant Professor of Civil Engineering, College of Applied Science, Syracuse University, Syracuse, N. Y.

CAREY, R. H., Instructor, Department of Engineering Mechanics, The Pennsylvania State College, State College, Pa. For mail: University Club, State College, Pa.

CLEMENS, E. C., Ceramic Engineer, Cannelton Sewer Pipe Co., Cannelton, Ind.

EDUCATIONAL BUYERS ASSN., New York City. For mail: O. J. Carner, Chairman, Product Testing Committee, Western Reserve University, Cleveland, Ohio.

ESKIN, S. G., Director of Research, Robertshaw Thermostat Co., Research Laboratory, 1201 Washington Boulevard, Pittsburgh, Pa.

HUBBARD, P. M., Treasurer, M. D. Hubbard Spring Co., S. Saginaw and Jessie Sts., Pontiac, Mich.

KIRCHHOFF, R. C., State Architect, Bureau of Engineering, Capitol Building, Madison, Wis.

KROGH, A. T., Section Engineer, Feeder Engineering Dept., Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

LEE, JULIA SOUTHARD, Department of Textiles and Clothing, Iowa State College, Ames, Iowa.

PATTERSON, E. C., Secretary and General Manager, Chattanooga Boiler and Tank Co., Box 110, Chattanooga, Tenn.

MINNEAPOLIS PUBLIC LIBRARY, Lois M. Jordan, Head of Order Dept., Tenth and Hennepin, Minneapolis, Minn.

STROHMENGER, N. C,, Chief Metallurgical Engineer, The Tool Steel Gear and Pinion Co., Elmwood Place, Cincinnati, Ohio.

Junior Members (2)

COHEN, SARA, Research Librarian, J. J. Berliner and Staff, 225 Fifth Ave., New York City.

DUNNE, B. A., Chemist, Socony-Vacuum Oil Co., Inc., Olean, N. Y. For mail: 704 Washington St., Olean, N. Y.

PERSONALS

News items concerning the activities of our members will be welcomed for inclusion in this column.

W. M. COY, formerly Director of Research, Wilson Sporting Goods Co., Chicago, Ill., is now connected with the United States Rubber Co., Golf Ball Dept., New York City.

F. A. KARTAK, Dean, College of Engineering, Marquette University, Milwaukee, Wis., has been elected president of the Engineers Society of Milwaukee, succeeding G. G. POST, Vice-President in Charge of Power, Wisconsin Electric Power Co., Milwaukee.

F. F. COLCORD, Vice-President and Manager of Metal Sales, United States Smelting and Refining Co., New York City, has been made a member of the executive committee of the Engineering Foundation.

J. W. SCHMIDT, who was Mechanical Engineer, Prophylactic Brush Co., is now Mechanical Engineer, Leominster Tool Co., Leominster, Mass.

J. C. SPRAGUE is Developing Engineer, Dravo Corp., Pittsburgh, Pa. He was formerly in the U. S. Engineer Office, Huntington, W. Va.

At the recent meeting of the American Society for Metals the following A.S.T.M. members were elected to office: *President,* J. P. GILL, Chief Metallurgist, Vanadium-Alloys Steel Co., Pittsburgh, Pa.; *vice-president,* O. E. HARDER, Assistant Director, Battelle Memorial Institute, Columbus, Ohio; *treasurer,* K. R. VAN HORN, Research Metallurgist, Aluminum Company of America, Cleveland, Ohio; *trustees,* D. S. CLARK, Assistant Professor of Mechanical Engineering, California Institute of Technology, Pasadena, Calif.; H. J. FRENCH, In Charge, Alloy Steel and Iron Development, The International Nickel Co., Inc., New York City; M. A. GROSSMANN, Director of Research, Carnegie-Illinois Steel Corp., Chicago, Ill.; and F. B. FOLEY, Superintendent of Research, The Midvale Co., Philadelphia, Pa.

G. T. HORTON, President, Chicago Bridge and Iron Co., Chicago, Ill., was elected president, and L. S. MOISSEIFF, Consulting Engineer, New York City, vice-president of the American Welding Society at its recent meeting. L. C. BIBBER, Welding Engineer, Carnegie-Illinois Steel Corp., Pittsburgh, Pa., was made vice-president of the Middle Eastern District, and A. J. MOSES, General Manager, Combustion Engineering Co., Inc., Hedges-Walsh-Weidner Division, Chattanooga, Tenn., vice-president of the Southern District. G. F. JENKS, Colonel, Ordnance Dept., U. S. Army, Washington, D. C., and H. S. SMITH, Consulting Engineer, Carbide and Carbon Chemicals Corp., New York City, were elected directors at large.

C. S. BARRETT and R. F. MEHL, Carnegie Institute of Technology, and G. Ansel, Dow Chemical Co., received the Henry Marion Howe Award made annually by the American Society for Metals for their paper entitled "Slip Twinning and Cleavage in Iron and Silicon Ferrite."

W. M. SCOTT, formerly Consulting Chemist, Gustavus J. Esselen, Inc., Boston, Mass., is now in the Regional Laboratories, Bureau of Agricultural Chemistry and Engineering, Washington, D. C.

C. H. CARMICHAEL is connected with the Grays Ferry Brick Co., Philadelphia, Pa., as Plant Manager. He was Manager, Atlantic Brick and Tile Co., Watertown, Mass.

The following members were elected to office by letter ballot of the members of the American Institute of Mining and Metallurgical Engineers: *vice-president,* W. M. PEIRCE, Chief of Research, The New Jersey Zinc Co., Palmerton, Pa.; *directors,* H. J. BROWN, Consulting Engineer, Boston, Mass., and F. E. WORMSER, Secretary and Treasurer, Lead Industries Assn., New York City.

NECROLOGY

We announce with regret the death of the following representatives:

SAMUEL ECKELS, Chief Engineer, Pennsylvania State Highway Dept., Harrisburg, Pa.

E. L. HIRT, Mechanical Engineer, Canadian and General Finance Co., Ltd., Toronto 2, Ont., Canada.

R. S. MACPHERRAN, Chief Chemist, Allis-Chalmers Manufacturing Co., West Allis, Wis. Mr. MacPherran had been connected with the Society since 1902. He represented his company on Committees A-1 on Steel and Subcommittees VI, VIII, XV, and XXI; A-3 on Cast Iron and Subcommittees VI, XV, XVI, XVII, XVIII, XIX and served as Chairman of Subcommittee XI; B-2 on Non-Ferrous Metals and Alloys and Subcommittees I, III, and V; B-5 on Copper and Copper Alloys, Cast and Wrought; and D-5 on Coal and Coke, and represented Committee A-3 on Committee E-1 on Methods of Testing and several sections. He was also formerly a member of Committees A-4 and D-2.

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